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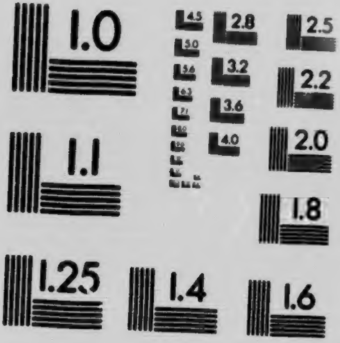

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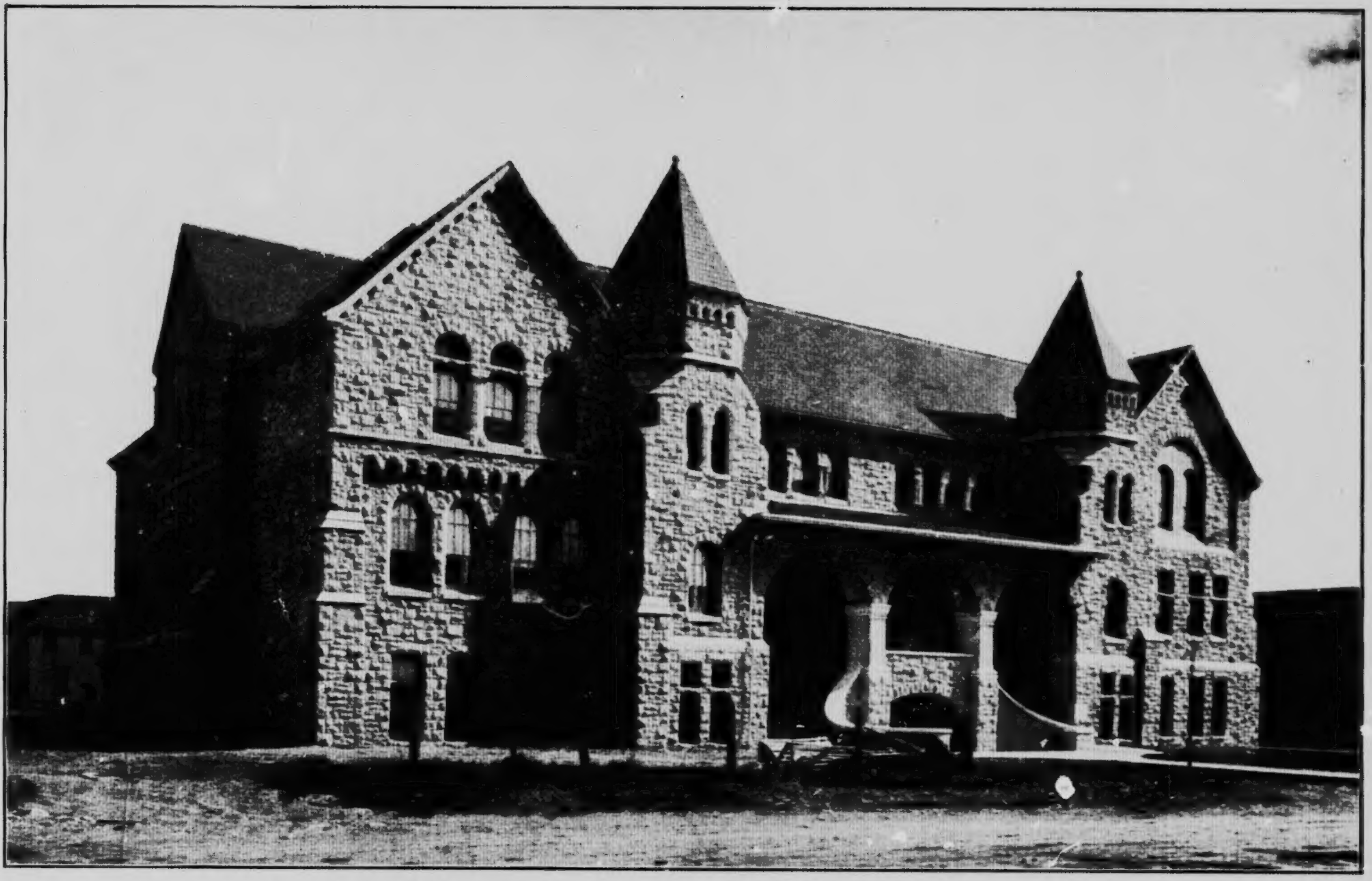

Geology and Mineralogy building, School of Mining, Kingston : built of Kingston limestone.

Geology and Mineralogy building, School of Mining, Kingston: built of Kingston limestone.

REPORT OF
THE BUREAU OF MINES, 1904
PART II.

THOS. W. GIBSON, Director

THE LIMESTONES OF ONTARIO

BY

WILLET G. MILLER, Provincial Geologist

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PREFACE

In the following Report on the Limestones of Ontario an attempt has been made to give a brief account of the present uses of limestone and lime, but the object chiefly sought is to show where limestones of various chemical compositions are to be found. For convenience in reference and to assist those who are in search of raw materials of particular kinds the limestone localities in the Province have been arranged under the headings of counties and districts. If attention is paid to what is said on a following page concerning the characteristics of certain limestone formations, the searcher for stone of a special chemical composition, after referring to the map on page 23, will have little difficulty, by merely reading the report, in locating areas in which suitable outcrops are to be found. Details can be gained by field work.

Although the report contains only one hundred and twenty-six pages, its preparation has entailed much labor. Literature, published during the last sixty years on the limestones of the Province, and special treatises and reports on other countries, have had to be consulted. The report contains over two hundred and sixty extracts from papers by various writers.

Since the preparation of the report was begun, two or three industries, which use limestone or lime as a raw material, have come more prominently before the public. Among these are "sand-lime brick" and "hydrated lime." Even at the present time it is difficult to get much reliable information on these industries.

HYDRATED LIME

In the manufacture of hydrated lime sufficient water is added to quick lime to satisfy its chemical affinity for water. The equation which represents the union of the two substances is:—CaO (quick lime) + H_2O (water) = $Ca(OH)_2$ (hydrated lime). In other words water is added to take the place of the carbon dioxide which has been expelled on the burning of the limestone to quick lime, as shown by the following equation:—

$CaCO_3$ (limestone) = CaO (quick lime) + CO_2 (carbon dioxide gas).

It is a well known fact that quick lime gradually slakes on exposure to the air and passes back into calcium carbonate, $CaCO_3$. It is found that hydrated lime, $Ca(OH)_2$, does not exhibit this tendency to take up carbon dioxide, and that its strength is not lost when it is kept in storage under ordinary conditions.

In order to know what percentage of water should be added to a given mass of quick lime to produce hydrated lime, it is necessary to know the percentage of lime (calcium oxide) and magnesia (magnesium oxide) in the quick lime. Theoretically, 56 parts of calcium oxide require 18 parts of water, and 40 parts of magnesia require the same amount. A ton, 2,000 lb., of quick lime which contains, for example, 60 per cent. of calcium oxide (lime) and 35 per cent. of magnesia will require:—

$$\left(\tfrac{18}{56} \times \tfrac{60}{100} \text{ of } 2{,}000\right) + \left(\tfrac{18}{40} \times \tfrac{35}{100} \text{ of } 2{,}000\right) = 385.7 + 315 = \text{[illegible]}$$

of water.

On account of the fact that heat is generated in hydrating lime, more or less water is evaporated during the process. Hence it is necessary, if water is added in the open, to add more than the theoretical amount. Lime high in calcium oxide will generate more heat during the process of hydration than lime made from dolomite.

Of course if more water is added to quick lime than is required to form hydrated lime, the product will tend to become pasty. On the other hand sufficient water should be added to avoid the chance of some of the quick lime not being hydrated.

The stages in the manufacture of hydrated lime used in one factory are: (1) Grind quick lime to state of fine division; (2) Add water; (3) Put in agitator and thoroughly mix; (4) Put in bins and allow to cool for a few days; (5) Draw off and sift. It may be added that in the last stage instead of using extremely fine silk screens for sifting or bolting as formerly, air separators are now used in some factories.

Hydrated lime is used in the same way as quick lime for any of the purposes to which the latter is applied. Being in the form of powder it can be mixed dry with other materials and thus has some advantage over quick lime. It is easier to handle than the latter, as it can be shipped in bags like cement. It would appear that the uses which are being found for it are likely to considerably enlarge the consumption of quick lime from which it is made. The two substances are sold at about the same price, the water in hydrated lime counter-balancing its greater cost of manufacture.

In addition to its employment in mixtures for dry mortar, which is ready for use on the addition of water, hydrated lime seems to have a large field as a substance suitable for mixing with Portland cement. Mixtures of the two sell at a lower price than pure Portland cement, and it is claimed that when equal amounts of the two are mixed together they produce a mortar of any strength required under ordinary conditions. Such a mortar is said to work smoothly under the trowel, and to give greater spreading qualities than the ordinary variety, thus accelerating brick-laying and similar work. The use of lime in cement is believed to render the finished work more water proof.

SAND-LIME BRICK

Since the manufacture of sand-lime brick appears likely to become a very important industry within a few years, in which case it will consume a large quantity of lime, it will not be out of place to give a brief account of the process of manufacture.

The raw materials used are sand and lime. These are well mixed together, moulded, and hardened by being subjected to the action of steam under pressure. This variety of brick should not be confused with what is known as silica-brick. The latter is used for refractory purposes and is also made from sand and lime, but comes more properly under the head of vitrified brick, since, in the process of hardening, the lime and part of the sand are fused together, producing anhydrous calcium and magnesium silicates. In the production of sand-lime brick on the other hand, the lime and part of the silica unite to form hydrated calcium silicate, and closely related compounds.

In the manufacture of silica-brick about three per cent. of lime is used, while in the sand-lime variety the percentage employed is from 5 to 10.

Any lime can be used in the manufacture of sand-lime brick, but fat limes or those high in calcium oxide are preferred to those containing much magnesia. Hydrated lime is being extensively used. Almost any variety of ordinary sand can be used, but there should be a certain percentage of very fine particles.

It is said that the first experiments in the manufacture of bricks from sand and lime were made at Potsdam, Germany, a little over thirty years ago. The city is situated in a region in which clays and building stone are scarce, but is surrounded by sand plains. Hence attention was attracted to sand as a source of building material. The bricks were first hardened by simple exposure to the air, a process which required several months but produced good bricks. About 1880 the discovery was made that the freshly pressed bricks of sand and lime could be hardened in a few hours by steam under pressure. Since then the industry has reached large dimensions in Germany. It is only within the last three years that it has received much attention in America. The majority of the seventy-five or more manufacturers in the United States began production in 1904. Plants are in operation in about thirty states. Companies have been incorporated in Canada, at Brandon, Ottawa and Montreal.

The rapid growth which the industry has made in Germany and in the United States is shown by the following: In the former country there were five factories in operation in 1896. In 1903 the number had risen to about 200, with an annual output of between 350,000,000 and 400,000,000 bricks. Within about three years from the time the first factory was erected in the United States seventy-five or more were in operation.

The natural color of sand-lime bricks is white or gray, but they can be produced in any color desired by adding pigments to the raw material before it goes to press.

In sections of the country where sand is plentiful and brick clays scarce, sand-lime bricks, it would appear, will be the building material of the future. The fuel cost is comparatively low.

SLAG CEMENT

Slag cement, produced from blast-furnace slag, is becoming an important competitor in some parts of the world with Portland cement. The two materials possess similar properties, but the former is produced at a much lower price than the latter.

GENERAL NOTES

From what has been said in the above paragraphs it will be seen that constant and very rapid changes are in progress in the industries which use limestone or lime as a raw material. A report such as this one on the Limestones of Ontario soon gets out of date so far as the information concerning industries is concerned. The data on the character and distribution of raw materials have a more permanent value.

No attempt has, however, been made in the following pages to give details concerning processes. The man who desires to keep abreast of the times in regard to the particular industry with which he is connected should subscribe for and read some reliable technical journal. Such publications dealing with almost every industry are now to be had.

Since the report was written an international committee, appointed by the Geological Surveys of the United States and Canada, on pre-Cambrian nomenclature, has decided on a new classification. Among the changes proposed is the use of the word Laurentian in a more restricted sense than formerly. The name is now to be applied only to granites and gneisses of pre-Cambrian age, and does not cover the crystalline limestones of the Grenville series, which are called Laurentian in a few places in this report.

As some of the analyses of limestones in the report are given in terms of the carbonates of calcium and magnesium, and others give the percentages of lime, or calcium oxide, and magnesia together with carbon dioxide, it may be well to state, for the benefit of those who do not possess a knowledge of chemistry, the method of determining what amounts of the carbonates the percentages of the oxides represent and vice versa.

The percentage of calcium carbonate in a limestone is equal to the percentage of lime, or calcium oxide, multiplied by 100 and divided by 56. For example, a limestone which contains 54 per cent. of lime contains $54 \times \frac{100}{56} = 96.4$ per cent. of calcium carbonate. On the other hand, a limestone with 90 per cent. of calcium carbonate contains $90 \times \frac{56}{100} = 50.4$ per cent. of lime.

To change the percentage of magnesia or magnesium oxide to magnesium carbonate, multiply by 84 and divide by 40. A limestone containing 20 per cent of magnesia has $20 \times \frac{84}{40} = 42$ per cent. of magnesium carbonate. A rock with 30 per cent. of magnesium carbonate contains $30 \times \frac{40}{84} = 14.2$ per cent. of magnesia.

W. G. M.

REPORT OF THE BUREAU OF MINES

1904

Vol XIII **Part II**

Thos. W. Gibson, Director

Limestones of Ontario

By Willet G. Miller

During recent years the Bureau of Mines has received frequent inquiries as to whether limestones of suitable quality for various industries, in which these rocks are now being used, were to be found in the Province. There being no systematic description of our limestones, it has often been difficult, or even impossible, to satisfactorily answer these inquiries. Many analyses of Ontario limestones have been made during the last fifty or sixty years, but the descriptions of the quarries and outcrops are scattered through many reports, and are thus accessible with difficulty to the public. The writer accordingly undertook the preparation of the present report. As he has been able, owing to duties in connection with other mineral industries, to give only a part of his time during the past season to field work on the limestone areas, it has been found impracticable to visit certain of the important localities. In order, however, to give some account of the limestones of all parts of the Province, copious extracts have been made from the Reports of the Geological Survey of Canada and other publications, many of which are long out of print.

The chemical composition of the samples collected has been determined by Mr. A. G. Burrows, analyst to the Bureau.

It is hoped that the collection of analyses and descriptions herewith presented will serve in some measure at least to fill the need that has existed for information on this division of our mineral resources.

Value of Limestones.

Many States of the Union and other countries have published elaborate reports on limestones and the industries in which they are used as raw materials. In Ontario few of our people yet realize that limstones form an important part of our mineral resources. The writer, while in the field during the past summer, felt that many persons misunderstood the nature of his work. Limestone to them was common rock and nothing more, recalling Wordsworth's lines:—

"A primrose by the river's brim
A yellow primrose was to him
And it was nothing more."

When one is seen breaking off samples, "pounding the rocks," many persons think that he must be after gold or some other precious metal. It is not realized that during recent years a number of important industries have either come into being or have been perfected which depend on limestone as a base. A good limestone deposit, if favorably situated, may be of as much benefit to a community as a metal mine.

The State Geological Surveys of both New York and Michigan have published important reports on limestones. The report of the former State is by Dr. Heinrich Ries, and is entitled "Lime and Cement Industries of New York." An interesting account of the marls of Michigan is given in the seventh volume of the Survey Reports of that State. Since the limestone formations in these two States are so similar to most of those of Ontario, the two reports mentioned are of much value to us.

Uses

Although the quantity of rock used in some industries is not in itself of great money value, still it is impossible for certain works to be established in a locality where limestone of suitable quality cannot be obtained at a satisfactory price.

Industries that were not dreamed of twenty years or less ago are now firmly established. One of these is the manufacture of calcium carbide, which has developed into a world-wide industry. Ten years ago the manufacture of Portland cement was but a business almost unknown on this continent. It has now become one of the greatest in America. In Ontario much capital has been invested in it, and well-situated deposits of marl and limestone are eagerly sought for. Then, within the last two or three years several beet-root sugar factories have been built in the Province. These require lime of a very pure quality. Our wood-pulp industry is also a growing one, and it is believed that it will in time add much to the wealth and prosperity of our population. The sulphite pulp process requires a limestone high in magnesia, of quite different character from that used in the manufacture of beet-sugar. Our smelting industry is also becoming greater yearly, and limestone suitable for certain smelters sometimes has to be sought for at a distance, e.g., limestone occurring near the town of Renfrew has been found to be of the quality required at Sudbury, and has been quarried and shipped thither. In the varied industries in the vicinity of Sault Ste. Marie limestones of three or four kinds are required. One quarry has been operated on an island in Georgian Bay and two others were purchased in the State of Michigan. If we had had a fairly complete knowledge of the limestones situate adjacent to the Ontario shore of Lake Huron, it is probable that it would not have been necessary for the company to go out of the Province in order to find this part of their raw materials. It is believed that this Province has vast undeveloped iron deposits. Some of these are situated within easy access of the great lakes, and the ore can be shipped without difficulty. Other deposits lie at such a distance from water routes that if they are to be worked the ore will have to be smelted on the ground, and the fuel must be charcoal. In reducing wood to charcoal, valuable by-products are formed. One of the most important of these is acetate of lime. In the preparation of this material a pure lime is required. Thus it is seen that, in the manufacture of charcoal iron, limestone is required, not only for smelting the ore, but also in the preparation of one of the wood distillates. As there are very few occurrences of ordinary solid limestone in some of the more remote northern parts of the Province, it would seem that some of the marl deposits in lakes and marshes are likely to become of economic importance.

It is easy to demonstrate that limestone plays a very important part in the industrial economy of any nation. Having in abundance raw materials or unused resources in connection with which for many purposes limestone is required, or can be profitably employed, especially timber, iron ore and water power, our limestones should be considered as being among our valued assets. An accurate knowledge is required of them for use in those industries which are capable of great expansion in the Province.

At the present time the value of the products of three or four of our industries in which the rock plays an important part, represents about 20 per cent. of our total annual mineral production of over $13,000,000. Limestone has as great a bearing on the wealth of other countries.

The following is a list of manufactures and industries—arranged in alphabetical order—some, of course, consuming only a small amount of lime, in which limestone is used as a raw material: Acetate of lime, agricultural uses, ammonium sulphate, beet sugar, bone ash, building stone, calcium carbide, carbon dioxide, cement (natural and Portland) chalk, chloride of lime, as a dehydrating agent, disinfectant, in dyeing, gas manufacture, glass, furnace linings, lime for mortar and whiting, lime pencils used in the oxyhydrogen light, lime water, lithographic stone, marble, as a polishing material, potassium dichromate, pottery glaze, for preserving eggs, etc., pulp and paper making, as a chemical reagent, silicate brick, smelting of iron, lead, etc., soap, soda manufacture, tanning.

It would be impossible to treat fully of these uses in the space available in a report of this character. An attempt will, however, be made to give information of a general nature, adapted to the needs of those who may desire to learn to what use certain materials can be applied. The technical man or specialist in lime, cement and other industries has much valuable literature available among the numerous treatises which have been published during late years. This report, it is hoped, will be of value to the specialist in informing him where he can procure in the Province limestones of various qualities.

The following contractions are made in the references to previous publications, viz.: G.S.C., Report of the Geological Survey of Canada; B.M., Report of the Bureau of Mines, Ontario; Roy. Com., Report of the Royal Commission on the Mineral Resources of Ontario, 1890.

Acetate of Lime

In the preparation of this material, from one of the distillates produced in the manufacture of charcoal, it is desirable to have as pure a lime as is obtainable. Magnesia and other materials serve no purpose, except to add to the weight of the acetate of lime and thus increase the cost of freight and handling when shipment is made to works where the acetic acid is extracted from the compound. It is likely that much charcoal will be produced in this Province, where coal is lacking for metallurgical and other uses, so that it becomes important to know the location of deposits of limestone adapted to this use.

There are already four charcoal plants in Ontario—at Sault Ste. Marie, Longford Mills, Fenelon Falls and Deseronto. At the first and last-mentioned places the charcoal is consumed chiefly in blast furnaces.

Suitable limestones for making acetate of lime occur in the Trenton group, and in the Corniferous; certain crystalline limestones of the Laurentian system also possess the right chemical composition.

Agricultural Uses of Lime

Lime, added to certain soils, has a beneficial effect, especially on those of a heavy clay character. It makes the soil work more easily, promotes drainage and causes a more rapid decomposition of vegetable matter. A certain amount of lime is necessary in soil as food for plants. Its effects on soil are, therefore, both physical and chemical. Magnesian limes have been held to be less suitable for agricultural uses than those which contain little or no magnesia. Some limes contain small amounts of phosphate and potash, substances essential to plant life, which adds to their value as fertilizers.

Ammonium Sulphate

In the production of liquid ammonia from ammonium sulphate the latter material is decomposed by lime, usually in the form of milk of lime, with the separation of calcium sulphate and ammonia. Caustic lime is, however, employed at times with the object of utilizing the heat evolved in the process of slaking.

Beet Sugar

In the manufacture of this material a supply of very pure limestone is essential—unless, as in Europe, the more costly, but more effective and closely-related compound, strontia, is used in place of lime. Limestone, when burned, supplies two materials which are used in the production of beet sugar, viz., carbon dioxide gas and lime. The sugar factories of Ontario have used limestone from the quarries at Amherstburg and at St. Mary's. Analyses of the rock from these quarries are given under the headings of Essex and Perth counties respectively.

Bone Ash

In the production of phosphate of lime from bones lime is used to precipitate the impurities dissolved out of the bone by hydrochloric acid, the lime combining to form calcium chloride.

Building Stone

The use of limestone in the form of blocks for building and structural purposes has been considerably affected during the last ten years or so by the substitution of concrete—crushed stone and cement. Formerly, for instance, dimension stone was used exclusively in bridge work and for locks and other canal structures. On the Trent Valley Canal, however, concrete is being used in place of stone, and the same is the case in many of our railway bridges There are two reasons for this. Cement and crushed stone are more easily transported to the points where the work is carried on, and the cost of labor in concrete work is much less than where cut or dressed stone is used. Some large buildings in the Province are built of concrete, for example, the beet-sugar factory at Peterborough. Concrete blocks, which resemble those of stone, are also coming into use. Thus, while the stone industry in some respects is likely to become of less importance, it will grow in other directions.

Crushed stone is being extensively used in the paving of streets. Most of this is limestone, on account of this rock being more easily quarried and crushed than granite, trap and other crystalline rocks. Limestone holding flint, silicified fossils, etc., makes as good, and in some cases better, crushed stone than the purer varieties. Thin-bedded limestones are as suitable for crushing as thick-bedded ones. This has brought about the development of quarries, which in the old days could not have turned out material of much marketable value.

That dimension stone is still preferred to concrete, for some purposes, is seen in the fact that a large number of dressed blocks from the Crookston quarries, have been used during the last couple of years in the construction of the power plants at Niagara Falls.

Limestone is likely to be used for many years in the construction of important buildings in localities, as, for instance Kingston city, where material of good quality can be obtained at a low price. In the ordinary type of dwelling, however, even in such places stone, on account of its higher cost, is being replaced by brick.

The finer classes of marbles are now replaced to a considerable extent in interior decoration by artificial imitation materials, which cost much less and appear to serve the purpose as well as genuine marble.

To sum up, it can be said that, while the older stone industry is likely to become less important as the years go on, the newer, that of crushed stone, will reach such dimensions that there will be a gain in production.

It may be added that crushed limestone for concrete purposes sells at about $1.30 per cubic yard f.o.b. Toronto. Granite and trap bring as high as $1.65 per yard. Many thousands of cubic yards of crushed stone are used annually in this city. About five miles of macadam roads have been built some years. The fragments of rock for this purpose should have an average diameter of about two and one-half inches.

Calcium Carbide

The method of manufacturing this material, which has come widely into use during the last 10 years in the production of acetylene gas for illuminating purposes, is fully described in the earlier reports of the Bureau of Mines (Vol. IV., pp. 137 to 166, Vol. V., pp. 32-41, and Vol. VI., p.p. 26-32).

The raw materials used are lime and coke dust; it is said charcoal could be used if it were lower in price, and that it would be a more suitable material in some respects, being free from sulphur and other impurities found in coke.

The two materials, lime and coke, are reduced to fine powder, intimately mixed together—theoretically in the proportion, by weight, of 87 1-2 of lime (CaO) to 56 1-4 coke (C)—and fused into a mass in an electric furnace. The chemical equation which represents the reaction is: CaO (lime) + C_3 (coke) CaC_2 (calcium carbide) + CO (carbon monoxide).

When water is added to the fused material, calcium carbide, acetylene gas (C_2H_2) is given off. This reaction is as follows:

CaC_2 (calcium carbide) + H_2O (water) = $CaOH_2O$ (hydrate of lime) + C_2H_2 (acetylene).

"The hydrate of lime obtained from the decomposition of the carbide with water can be used again in the manufacture of the carbide, or it can be employed in the manufacture of ready-mixed mortar." (1) Concerning the value of the hydrate of lime produced by this decomposition it is further stated: "At the present time private information from America shows that calcic carbide can be produced at a little under £4 a ton, and the beautifully pure lime obtained by the decomposition would be worth to the gas manager at least 10s. a ton; and as a ton of the carbide will give rather more than 1 1-4 tons of quicklime, or 1 3-4 tons of slaked lime, £3 10s. may be taken as the cost of the acetylene produced from a ton of the material." (2) As this statement refers to conditions that existed ten years ago, allowance will have to be made for the prices given. The object in giving the quotation is merely to draw attention to a source of pure lime.

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(1) B.M., Vol. IV., p. 161.
(2) Ibid, p. 147.

In the year 1903 the value of the calcium carbide produced in the Province was $144,000.

It will be seen from the chemical composition of calcium carbide that calcium (lime) is the only constituent of limestone that is used. Magnesia and impurities commonly present in limestone are objectionable; the higher the percentage of lime held by the rock, the better.

Calcium Chloride

This compound which is used as a drying agent on account of the fact that it absorbs water with avidity has the formula $CaCl_2 + 2H_2O$. Another similar substance, $CaCl_2$, possesses the same property and is used as a dehydrating agent, but it cannot be employed, like the former, in cases where carbon dioxide is present, without absorbing it.

These two materials are produced from the normal chloride, $CaCl_2 + 6H_2O$, by heat. If care is taken not to heat this chloride above 200 deg. $CaCl + 2H_2O$ results. If the temperature is raised above this point $CaCl_2$ is formed

The normal salt is produced, along with carbon dioxide, when limestone is treated with hydrochloric acid, and the reaction is represented thus:

$CaCO_3 + 2HCl\ (5H_2O) \qquad (CaCl_2\ 6H_2O) + CO_2$.

Carbon Dioxide

This material, commonly called carbonic acid gas, has several uses in the arts. It is most commonly obtained from limestones for commercial purposes by heating them to such a temperature that decomposition results, quicklime and carbon dioxide being formed. The gas may also be extracted from these rocks by treating them with acids, when effervescence takes place and the gas is liberated. At several well-known places carbon dioxide issues from the crust of the earth; and at one locality in New York State the gas originating in this way is collected and used.

The method of producing carbon dioxide and the use mad[illegible] in the beet sugar industry have [illegible]y been mentioned.

Liquid carbon dioxide, formed by subjecting the gas to presssure, has come into use during recent years. It has been employed as a fire extinguisher and for charging liquids with the gas. The use of gas in the so-called soda-waters is well known.

Dolomite and magnesite are preferred to stone high in calcium carbonate in the manufacture of carbon dioxide. Marl has been made use of at Buffalo.

Chalk

The use of this material for writing on blackboards is a very general one. It has been replaced to some extent for this purpose by crayons of talc or soapstone.

Chloride of Lime

This substance is commonly known as "bleaching-powder." Its chemical constitution is not definitely known but its formula is probably $CaOCl_2$. It is white in color, has the odor of hypochlorous acid, and is extensively used as a bleaching agent. It is also employed as a disinfectant, and as an antiseptic.

It is prepared by treating slaked lime with chlorine. The limestone used in the production of the lime should be very pure and thoroughly burned. If magnesia is present the compound tends to deliquesce and is less stable. Sand and clay should also be absent. If coloring materials, such as iron or manganese, are present in lime it is not adapted to this use.

Dehydrating Agent

Quick lime absorbs water with ease, and on this account is used to some extent for dehydrating alcohol and other materials.

Disinfectant

Owing to its strongly caustic character, quick lime is of use as a disinfectant.

Gas Manufacture

Slaked lime having an affinity for hydrogen sulphide and carbon dioxide is used for extracting these substances from illuminating gas.

Glass

The commoner varieties of glass are mixtures of the silicates of lime and soda. The raw materials are essentially lime, sand (silica) and sodium carbonate, which are melted together. Instead of lime, lead oxide may be used; and potassium carbonate may replace sodium carbonate. Ordinary window glass is a sodium-calcium glass. Instead of lime, crushed limestone is commonly used, on account of the fact that lime when stored may change in composition, before being used, by the absorption of moisture and carbon dioxide.

Limestone for glass-making should be free from coloring materials, such as iron. While magnesian limestones have been used, those practically free from magnesia are preferred, as this ingredient makes the glass less fusible.

The Corniferous limestones in the Erie and Huron area of the Province, and those of the Trenton group, farther east, are adapted to glass-making. Heretofore the lime used in the industry in the Province has been imported.

Below are given two analyses, No. 1 from Blair county (Pa.), and No. 2 from Sandusky (Ohio). The former is used for window glass, the latter for lime flint glass: (3)

	1. Per cent.	2. Per cent.
Lime carbonate	97.23	55.60
Magnesium carbonate	1.46	41.43
Silica	1.01	1.00
Alumina	0.03	0.40
Ferric oxide	.....	0.12
Ferric carbonate	0.165	.....
Organic matter	0.00	0.05
Moisture		0.40

Furnace Linings

Lime has been melted only at a very high temperature in electric furnaces. It therefore can be classed as a good refractory substance, and is used in lining parts of reverberatory furnaces in the manufacture of steel. In the Thomas-Gilchrist process the lime in the furnace serves an additional purpose in extracting the phosphorus from the iron. The lime phosphate thus produced has, moreover, a value as a fertilizer.

Oxyhydrogen Light

Lime has a high melting point, and emits an extremely bright light when the oxyhydrogen flame is impinged upon it, as in what is ordinarily known as the lime-light.

Lime Water and Milk of Lime

When quick-lime is treated with water it forms, as already stated, calcium hydroxide, $Ca(OH)_2$, or slaked lime. This substance is somewhat soluble in water, the solution being known as lime-water. The solution takes place with difficulty in cold water (1 part in 760 parts), and with still more difficulty in hot water.

The thick paste formed by slaked lime with water is known as milk-of-lime.

Lime-water has a strong alkaline reaction and combines with the carbon dioxide of the air to form calcium carbonate. Breathing through a tube into lime water also causes a white precipitate. A grotesque use of this has been made by quack doctors.

Lithographic Stone

The only limestone which has been found to be perfectly suited for use in the lithographic art, is, peculiarly enough, that first employed for the purpose, which is obtained from the Upper Jurassic strata at Solenhofen, in Bavaria. The stone is not only rare, but valuable. It has been sought for in many parts of America, but with little success. Stone from various States has been used to a limited extent. Ontario has probably produced as much as any other part of America. Although, however, attempts have been made to establish an industry here during the last fifty years, little progress has been made, and no lithographic stone has been quarried for some years.

The requirements for a good stone are that it shall be fine in grain, of a homogeneous texture, not too dark in color, and free from quartz, pyrite and other minerals which are commonly found in limestone. It should, moreover, possess sufficient porosity to absorb ink and be soft enough to be worked readily with an engraver's tool. Varieties which possess most of the other requisites are often brittle and cannot be gotten out in pieces with large surfaces.

In Ontario lithographic stone has been quarried chiefly in the Black River formation near the village of Marmora, in Hastings County. This formation, which bounds, on the south, the Laurentian area, runs in a band from Kingston city to the Georgian Bay. Certain strata in the formation throughout the whole distance possess lithographic properties, but usually are defective owing to the development of small crystals of calcite. In the township of Rama, on Lake St John and Lake Couchiching, similar strata to those of Marmora have been tested. Thin sections taken respectively from the Marmora and Bavarian stone showed considerable difference when examined microscopically by the writer. The Marmora stone exhibited a more uneven texture owing to the presence of secondary crystals of calcite, while the Bavarian was uniform in character.

Strata in the Niagara formation at the head of Lake Temiscaming have also attracted attention as being of possible value for lithographic purposes; as have also certain strata in the township of Brant near Walkerton.

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(3) Bull. 44, N. Y. State Museum, p. 654.

Lime

Before proceeding further with the description of the uses of limestone and lime, it will be well to discuss briefly the burning and slaking (4) of lime.

Lime Burning

The burning of lime is an operation similar to that which, when other materials are dealt with, is known as calcining (from the Latin calx, calcis, lime, since limestone was apparently the first substance thus treated). In burning limestone or calcining other substances gases and vapors are driven off and the substances themselves are reduced to powder or to a friable condition.

The receptacle in which lime is burned is known as a kiln (a word which is closely connected in origin with the word coal). Lime kilns are varied in form, ranging from the cruder kinds, which consist of a few loose stones, built into an enclosure, to the more highly developed forms, lined with brick or iron, which show almost as much ingenuity in construction as do furnaces used for metallurgical work. In remote districts limestone has often been burnt by piling it on a log heap or brush pile.

At the present time a comparatively small proportion of the lime [illegible] in Ontario is made in the [illegible] pot kiln. The bulk of the [illegible] has gone into the hands of a few companies and individuals, operating in [illegible] about 30 draw kilns located at points convenient to the chief markets.

The pot or set kiln has among its disadvantages that of being intermittent in operation, necessitating loss of time for cooling after burning and before drawing and recharging; while the draw kiln is continuous.

A rectangular exterior of rough stones enclosing in heavy walls a pot-like cavity 8 to 10 feet in diameter by 10 to 14 feet deep composes a pot kiln. The charge is fired and drawn through a single grate chamber, say, 15 inches wide, which runs from the front, underneath the kiln, to the rear wall. Frequently these kilns are built in a series in one continuous structure. A pot kiln 8 feet in diameter by 10 feet high will hold about 800 bushels of lime, and requires between three and four days for a burning, with a consumption of 20 cords of wood.

The draw kilns of to-day differ very little from the first ones erected 15 or 20 years ago; in fact, some of the latter are still in use, but with labor-saving improvements, in many cases, in methods of charging or loading and of drawing the kilns. A kiln of the latest design will have approximately the following dimensions: outside, 18 feet by 22 feet plan at bottom, tapering slightly towards the top, 53 feet high, and with an arched way beneath, into which tram cars run to receive the charge of burnt lime on drawing from the bottom of the kiln; interior of furnace (cylindrical) inside the fire-brick lining, 2 feet in diameter at the bottom at the discharge gate, 6 feet 4 inches by 9 feet 6 inches at the fire-boxes 12 feet above the discharge gate, 6 feet 2 inches by 9 feet 2 inches at 12 feet higher still, and the same cross-section as at the fire-boxes at 13 feet higher or at the top of the fire-brick lining of the kiln; at this point and to the top 8 feet higher the kiln widens out into the charging or loading hopper 2 1-2 feet greater in cross-section. There are four fire-boxes, built in pairs opposite each other in the longer sides of the kiln; above them the charge of limestone is subjected to the flames, while below in the 12-foot drop to the discharge gate it has a chance to cool before being drawn. These are the maximum figures for the kiln burning gray limes where the limestone is porous and allow the gases of combustion, etc., to escape with the least hindrance. A kiln burning lime from compact limestone may have to be built 10 feet shorter and proportionately smaller in cross-section in order to prevent the charge choking the draught.

The kilns are built of stone, with walls of a minimum thickness of 6 feet, braced outside at intervals from top to bottom with heavy logs or I-beams and tie rods to counteract bulging. Where possible a site is chosen for the kiln directly below the quarry, so that the top of the kiln will stand about level with the floor of the quarry to facilitate loading.

Broken stone in all sizes up to 10 or 12 inches, excepting the fine material, is charged in for a heaping load twice every 24-hour day, and at the same time one-half ton or so of fine coal mixed in to help heat the upper portion of the charge preparatory to its arrival opposite the fire places. Porous, quick-burning gray limes may usually be drawn every four hours, whereas the more compact, hard limestones frequently take six hours for complete elimination of the carbonic acid gas. The maximum output per 24 hours of any such kiln amounts to about 500 bushels, and the minimum to about 300 bushels, depending on the size of furnace and quality of stone. One kiln producing 400 bushels per 24 hours uses in the same period seven cords of hardwood.

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(4) Two verbs of similar form are used in the same sense—slake and slack. In the former the sound of the letter a is long, in the latter short.

The fuel used in lime kilns is of various kinds—wood, coal and gas being used. Natural gas, where available, is one of the most suitable fuels, and several kilns in this Province, in the vicinity of Port Colborne, make use of it.

During late years in many of the more thickly populated parts of America wood has become scarce and too costly to be employed as a fuel in lime-burning. This has brought about the more common use of coal and the death of very many of the small lime-kilns, which in some sections of the country were found on almost every farm. More attention is being paid to the loss of fuel which took place in the older types of kilns, and some of those recently invented, in which coal is used, are much more economical of both fuel and labor.

At the present time about half of the operating draw kilns are burning coal. Coal fires have not so long a flame as wood, partly because the draught must be considerably checked in order not to exceed the permissible maximum temperature in the kiln, and partly because the combustion or heat thereof is of a much more concentrated form. These conditions are adverse to lime burning, but may be overcome in part by a reduction in the cross-section of the furnace at the fire-places. In addition, however, a strong draught must be generated, as subsequently explained, to overcome the dissociation-pressure of the carbonic acid gas in the furnace. To do this, without making too hot a fire, the natural draught of air is supplemented by mixing with it in about equal quantities a portion of the inert gases (largely carbonic acid gas) from the interior of the kiln. By means of piping, a blower and a gasoline engine, a portion of these inert gases is drawn off from the upper part of the kiln, mixed with the required amount of air and forced under the fires at the desired pressure. The flames are carried to all parts of the charge and a good upward draught maintained without overheating the lime.

Different limestones require different treatment, both as to temperature and as to strength of draught, on account of which coal fuel has at first frequently been considered inferior to wood. However, with a knowledge of the principle of burning the new fuel, and after a few days' careful experimenting, there appears nothing to hinder making just as good lime with coal as with wood.

During the year 1903 the lime kiln operators in Ontario numbered 190, their total output amounting to 3,400,000 bushels, valued at $520,000; of this, 85 per cent. was manufactured by 20 of them, giving to each of these an average production of 170,000 bushels. The remaining 170 operators turned out an average each of only 2,600 bushels, made doubtless in the old set or pot kilns. Fourteen years ago, in 1890, the Province contained 608 lime-burning establishments, and the production for that year was about the same as for 1903.

When limestone is burned under proper conditions it is broken up or dissociated into lime and carbon dioxide, as shown by the following equation:

$CaCO_3$ (limestone) + heat = CaO (lime) + CO_2 (carbon dioxide).

The characteristics of these substances are described on other pages of this report.

Carbon dioxide is a heavy gas, and does not pass out of the top of the kiln as a gas lighter than air would tend to do. This point is often not considered in the building of kilns, the construction frequently being such that much of the carbon dioxide freed from the first part of the limestone burned remains in contact with other parts of the heated stone and thus prevents the easy burning or calcining of those parts of the limestone which are immersed in an atmosphere of the gas.

Limestone is not decomposed at a low red heat, but is converted at a bright red heat into carbon dioxide and lime. The temperature at which the decomposition is effected, and consequently the amount of fuel consumed, depends upon the facility afforded the carbon dioxide for escape when it has been expelled from the stone. Hall found that pieces of limestone enclosed in a tube, and consequently under a high pressure, resisted decomposition, even at the temperature of the porcelain kiln, and melted with a loss of, at most, 1 per cent. It has also been shown that under great pressure, which is equivalent to a temperature at least sufficient to decompose the rock, if not under pressure, limestone can be moulded almost like putty without the loss of carbon dioxide (5).

The writer has been told by lime-burners that they find the rock to burn most readily when it is moist. Hence farmers and others who do their burning when most convenient prefer to carry on this work during the winter and spring, the periods of the year when the stone is most highly saturated with water. An experiment conducted by Gay-Lussac, many years ago, explains this phenomenon, of the apparently more easy burning of moist than of dry stone, and proves that it is due to the fact that the moisture volatilized from the stone tends to carry off the carbon dioxide evolved, thus, as already shown, promoting the calcining of the rock.

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(5) F. D. Adams and John T. Nicholson. An Experimental Investigation Into the Flow of Marble. Can. Rec. Sci., Vol 8. pp. 426-436, 1902. Also in Phil. Trans., Roy. Soc., London, series A, Vol. 195, pp. 363-401, plates 22-25, 1901.

Gay-Lussac, in the experiment referred to, placed pieces of marble (limestone) in a tube, which was so arranged in a furnace that the temperature could be easily regulated. One end of the tube was connected with an apparatus for the evolution of steam (steam is also, it should be noted, given off when moist limestone is treated), and the opposite end with a contrivance for collecting the carbon dioxide. The temperature was raised so high at first that the marble began to be rapidly decomposed, when, by impeding the draught, it was reduced to a dark-red heat, so that all evolution of carbon dioxide ceased. When water vapor was permitted at this moment to pass over the red-hot lime, carbon dioxide again made its appearance in considerable quantity, and continued to pass off under these circumstances in a manner entirely dependent upon the current of vapor. It stopped when the vapor was cut off, and began again immediately upon its admission. Hence, it follows directly that the decomposition of the limestone is effected at a lower temperature by the agency of water vapor (steam) than under ordinary circumstances. The same effect, however, may be produced by a current of air as by steam, and the action of the vapor is consequently only mechanical, tending to form an atmosphere around the blocks of limestone, which is void of carbon dioxide, and is thus in a fit state for being permeated by the gas, as a vacuum would be. In the one case, the escaping carbon dioxide has to overcome the pressure of that which has already been evolved, while in the other this is entirely obviated, the kiln being free from carbon dioxide, or filled with a gas of a different nature (6). It has also been shown that when quicklime is exposed to a current of carbon dioxide at a white heat, a temperature at which limestone is readily decomposed under ordinary circumstances, the lime absorbs sufficient of the gas to cause it to effervesce vigorously with acids, and is no longer slaked with water. In other words, the lime has been caused to take up carbon dioxide and to again become limestone.

The practice of burning moist limestone cannot, however, be considered an economical one, as fuel is consumed in expelling the moisture. The best type of kiln is that in which a current of air replaces that of steam or water vapor.

Carbon dioxide begins to be given off from limestone when the latter reaches a temperature of 750 degrees F., but decomposition is not complete till 1300 or 1400 degrees are reached. The more quickly limestone is burned at the highest temperature the more readily it slakes. In burning, the temperature should remain as constant as possible. When lime is overburned, it slakes slowly and incompletely. If the temperature, on the other hand, gets too low the cores of the larger lumps of rock in the kiln are left unburnt. A dense limestone is more difficult to burn than an open-textured one. Limestone containing clayey material is apt to sinter if heated to a high temperature. Part of the rock then remains unburned, being coated with a slag-like substance. Moreover, certain limestones containing clay produce hydraulic limes and cements, which harden under the action of water, as described under cements, and cannot be used as ordinary lime. Limestones containing sulphur are unsuited for the production of lime, since the sulphur oxidizes to sulphate, which in course of time reacts with alkali, and produces the white efflorescence frequently seen on brick work. When coal carrying sulphur is used as the fuel in burning, the same results are brought about.

In burning a pure limestone loses theoretically 44 per cent. of its weight by the escape of carbon dioxide. There is also a decrease in volume which is said to be usually 16 to 18 per cent., but ranges from 12 to 21 per cent. Lime has a specific gravity of 3.09. A bushel weighs 70 pounds.

In the cruder kinds of lime-kilns, the fuel comes in direct contact with the stone, the two materials often being in alternate layers. Such kilns are known as the intermittent kind. In the more modern, the kilns, which are usually cylindrical in form and lined with iron plates, instead of brick as formerly, are so arranged that the flame only comes in contact with the limestone. The fire boxes, supplied with grates, are built in the side of the kiln, some distance from the bottom, and the flame burns inward and upward through the rock. The burnt lime is drawn off from the bottom. Such kilns are known as continuous or draw-kilns. Burning the fuel in contact with the stone is objectionable, owing to the fact that ash becomes mixed with the burned lime and introduces impurities into it.

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(6) Knapp's "Chem. Tech.," 1st American edition, Vol. 2, pp. 356 and 357.

Lime Burning at Saw Mills

To give an idea of the cost of the production of lime when the quarries are situated near lumber mills, the following data taken from the report of Prof. L. W. Bailey may be used. (7). In comparing the cost of production of lime at St. John, N.B., with that at Rockland, Me., the industry at the latter place being favored by "a duty of six cents per 100 lbs., including the weight of the barrel, which was equal to 13¾ cents a barrel, or about twenty per cent. on the value as delivered in United States markets." Prof. Bailey goes on to say, "In several respects St. John has great natural advantages, making the competition more equal, one of these being the situation of the quarries and the facilities for shipment (the quarries at Rockland being distant two miles and a half from the kilns); and another, the cheapness of fuel, the latter consisting largely of the refuse from lumber mills. In several instances, indeed, as at Randolph and Baker's, the saw-mills and the lime-kilns are run by the same owners, side by side. The cost of Rockland limestone, placed in the kilns, is twenty cents a barrel, as against ten cents a barrel at St. John. The cost of kilnwood at Rockland is $3 for the small cord, as against $2 at St. John. Cordwood burned in a kiln at St. John costs ten cents for each barrel of lime, while at Rockland it is fifteen cents. The Rockland people estimate that their lime costs, ready for shipment, seventy-two cents per barrel, while the freight to Boston is thirteen cents and the price eighty-five cents, leaving no profit. The following figures show the corresponding cost at St. John:

	Cents.
Stone at kiln	10
Boring (labour)	5
Cordwood	10
Barrel	16¼
Trimming barrel	1½
Foreman	½
Repairs	½
Interest on investment ..	¾
Duty (to U. S.)	14
Freight (to U. S.)	18
Consular certificate......	½

Total, per barrel ....77 cents."

These figures should be of use to any person who contemplates starting a lime industry in Ontario, the conditions in some localities in this Province being almost the same as at St. John.

In order to give an idea of the size and character of the kilns from which these results are obtained the following description of the kilns at Randolph and Baker's saw mill, referred to above, may be quoted: "There are here two kilns, each with a capacity of 120 to 140 barrels of lime per day, and therefore for the nine months during which they are kept running—March to December—yielding from 25,000 to 30,000 barrels of lime. They are built of brick, faced with stone, about thirty feet in height; hopper-shaped inside for the upper third of the height, then with a straight funnel for the next third to the level of the fire, and again widening out to the lower floor, from which the lime is drawn. The limestone is put in at the rear of the kiln above, and the burnt lime drawn out from the front of the kiln below, while the fuel is fed in at the side, at the height of a few feet above the floor, from which the burnt lime is drawn. The two kilns are enclosed in a large gravel-roofed shed, which extends to the edge of the wharf, so that the lime is protected from the weather even when being shipped." (8)

Prof. Bailey's interesting summary of the lime industry in New Brunswick throws light on another subject which has been referred to by the present writer in this report, viz., the quality of lime produced from stone which carries a high percentage of calcium carbonate, and little or no magnesia. Speaking of the St. John lime, he says: "It has at all times been preferred to other limes for use in the Maritime Provinces, but as an article of export has only acquired importance in recent years." (9)

"The character of the St. John limestones is further indicated by the subjoined analyses, made in the laboratory of the Survey. Previous to analysis the specimens were dried at 100 degrees C., the hygroscopic water thus abstracted being as follows, respectively:—No. 1, 0.09 per cent., No. 2, 0.04 per cent., No. 3, 0.05 per cent. (10):

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(7) G.S.C., 1897, pp. 81, 82 M.

(8) G.S.C., 1897, p. 80 M.

(9) Ibid, p. 79 M.

(10) Ibid, p. 81 M.

	No. 1.		No. 2.		No. 3.	
Carbonate of lime		95.60		99.05		98.39
" magnesia		0.44		0.88		0.71
" iron		0.12		0.05		0.05
Alumina	0.11	4.27	0.01	0.23	0.02	1.19
Silica, soluble	0.16		0.09		0.04	
Insoluble mineral matter	3.54		0.11		0.82	
Organic matter	0.46		0.02		0.31	
		100.44		100.21		100.34"

Slaking of Lime

Little care is often taken in the slaking of lime. Much better results are obtainable, however, by following certain well-known principles. Lime when dry at ordinary temperature is unaffected by carbon dioxide, but when heated, as shown above, takes it up readily. It, however, combines with water with avidity, with the evolution of so much heat that sulphur can be set on fire and wood has even been ignited. The reaction which takes places during the union of water and lime—the change from quick-lime to slaked lime—is represented by the following equation: $CaO + H_2O = Ca(OH)_2$. The higher the percentage of oxide of calcium (CaO) contained in lime the more heat is given off and the slaking is correspondingly more rapid. Such limes are called fat limes, probably on account of the resemblance of the white, pasty mass produced to fat. Fat limes slake in the air by absorption of water vapor. Hence they should be protected from the atmosphere as much as possible. That slaked lime when so protected will keep indefinitely is shown from the statement that "in removing the ruins of the castle of Landsberg in order to lay the foundations for a new building, it is stated by Jahn, that a lime pit of considerable dimensions was found in one of the vaults. The surface of this mass of lime was carbonated to the depth of a few inches, but all below that was in the state of freshly-slaked lime, only somewhat more dry. This lime, which was certainly more than 300 years old, and valued at several hundred florins, was consequently used in constructing new buildings." (11)

Limes carrying smaller percentages of oxide of calcium are called lean limes.

The temperature of slaking should be attended to, as it influences the quality of the lime. When no more water is added to the lime than it can absorb, it does not form a soft, but a sandy powder, and is said to have been rendered poor by slaking.

Lime is divided by the trade into two main classes, white lime and gray lime. Besides the color, the other distinguishing points are the slaking and settling qualities, some limes acting more quickly in these respects than others, and also making a stronger set. As a general rule gray lime is employed for foundation mortars where the color is imm terial, and white lime for facing, in ior plastering, white mortars, etc. I building it is customary to pl the lime in slaking tubs, or in boxes constructed of boards, and pour as much water into them as nearly cover the lime. If lime is m ened with water in the dark it presents lively, luminous appearance.

Marble

In the trade the term marble is sometimes loosely used, being applied to various rocks. Properly, it should be restricted to a variety of limestone which is capable of taking a good polish and is suitable for use as a decorative material. These varieties are usually what are properly called crystalline limestones. Certain kinds of other limestones, especially some fossiliferous examples, also make handsome decorative materials.

Marbles are variously colored. Some of the most highly prized are mottled. Marbles which contain intermixed serpentine, such, for example, as that found near Charleston lake, in Leeds county, have a handsome appearance when polished.

In Ontario very little use has been made of the crystalline limestones which are adapted to decorative and monumental purposes. At the present time, so far as the writer knows, only two quarries are worked, and in only a small way, for marble. A local manufacturer at Renfrew uses a small amount of the white crystalline limestone from the quarry in the town for monuments. A small amount of pure white marble is also quarried about four miles from Haley station, west of Renfrew. This material has been used in some of the recently-erected public buildings at Sault Ste. Marie, and in combination with brick gives the buildings a rather handsome appearance. The dark-gray mottled marble which was formerly worked at Arnprior is referred to on another page, as are also the quarries which were opened near Madoc and Bridgewater. The quarries at the latter place have recently been made more accessible by the building of the Bay of Quinte railway northward from Tweed. Reference to marbles will be found under the headings devoted to counties and districts--Frontenac, Hastings, Renfrew, Algoma, Thunder Bay. It will be seen that the Province possesses a considerable variety in marble resources which are as yet practically undeveloped.

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(11) Knapp's "Chem. Tech."

The marble used in this country nearly all comes from the large quarries of the United States. Although we have native varieties that are as good, trade prejudices favor the imported article. Many of the cheaper kinds of tombstones are made of Vermont stone—chiefly the "Vermont blue"—but marble is also imported from Georgia, Tennessee and other States.

For interior decoration, such as wainscotting, imitation marble has replaced the natural material to a considerable extent.

Mortar

The [illegible] of lime in mortar appears to have [illegible] known in pre-historic times. Its employment is largely empirical, and little more is known, by many users, of the character of lime to-day than was known some centuries ago. The slaking of the lime and the mixing of mortar is often still carried on in a very crude way.

The effects produced by the presence of magnesia in quicklime are not well understood. Limestones carrying all percentages of calcium and magnesium carbonates, from none of the latter to the percentage which makes the rock what is theoretically a true dolomite, are burned for lime. Men who have always used the Niagara limestone, for example, say that in order to make good lime the rock must be magnesian, while other lime men and writers claim that 25 or 30 per cent. of magnesia renders the stone unfit for burning, notwithstanding the fact that such material has been used for years in some localities. This subject—the effects produced by magnesia—needs investigation. Theoretically it would appear that those limestones that carry the highest percentage of calcium carbonate are the most suitable for burning, but practically the presence of magnesia in lime used for ordinary purposes seems to [illegible] of no importance. In plaster magnesian lime sets more slowly, and thus has some advantages where time is needed to give a smooth finish to the surface before the plaster hardens. It would also seem that lime which is practically free from magnesia, although it may make a stronger material, needs more careful slaking than does magnesian lime. I am told that in some parts of Europe this fact is recognized, and that lime is sometimes slaked in underground pits for several months or a year before being used. This prevents "pitting" in plaster, which appears to be due to imperfect slaking, namely, the formation of small pits in the plaster after it has hardened. These are apparently caused by the gradual absorption of water and consequent swelling of small portions of lime, which were unslaked at the time the plaster was laid on the wall.

The water used in slaking the lime should not contain an appreciable amount of soluble salts, as these may effloresce in time and cause a white deposit on brick or stone work, thus marring its appearance. Sulphur, oxidized to sulphate, brings about the same effect.

After slaking, sand is added to the lime. The sand prevents shrinkage, and necessitates less lime being used. In course of time the slaked lime changes to carbonate by the absorption of carbon dioxide from the air, but the complete change of the hydrate to carbonate may take years.

In slaking very fat lime it is stated that about 2 1-2 volumes of water to one of lime should be taken. Magnesian limes require less. If an excess of water is used the temperature is lowered, and the slaking is incomplete. It is claimed that from 1.25 to 2 volumes of sand should be used to 1 of paste. This in the case of fat lime means 3 to 5 volumes of sand to 1 measured volume of lime, which gives a plastic mortar that does not crack.

"In the structures of the ancient Egyptians, as in the Great Pyramid, mortar was freely employed, but it consisted almost entirely of sulphate of lime. A specimen taken from an ancient Phoenician temple, the highest stone of which was a few years ago five feet below the level of the ground, was quite similar to that found in some of the castles in Europe, and was like a piece of solid rock. It was made of burnt lime, fine sand, coarse sand and gravel. It was a concrete rather than a mortar; the lime had become completely carbonated. Ancient Greek mortars from ruins in the neighborhood of Athens are in very perfect condition. They contain no gravel. Mortars from ruined buildings in Herculaneum, and from Rome and its vicinity, appear to have been made from burnt lime and puzzolana, or volcanic ash." (12).

"Common mortar is made with fat lime, and clean, sharp sands in the proportions, usually, of 1 to 5 by volume." (13).

Minor Uses

Limestone in a state of fine division may be used for polishing the surfaces of marble and other materials not possessing very great hardness.

In the manufacture of potassium dichromate from chrome ore, lime, as free as possible from silica and magnesia, is used along with alkaline salts.

In the manufacture of pottery, lime is used in the body of the ware and also as a constituent of the glaze.

On account of its disinfectant and antiseptic properties, lime is employed in preserving eggs, etc.

Lime-water and other compounds of lime are in frequent use as chemical reagents.

Lime plays an important part in the manufacture of soap. It is used to form caustic soda and potash from carbonate of soda and the pearl ash of commerce, respectively. It is also used in the saponification of tallow and in other ways.

In soda manufacture, by the Leblanc process, limestone is used to change the sulphate of soda into caustic soda.

In tanning, lime is employed to remove the hair from the skins.

Lime is also used to free the rags used in paper manufacture from dirt, and to decompose glutinous substances.

Pulp and Paper Making

In the manufacture of sulphite pulp a lime as high in magnesia as is obtainable is preferred, although other limestones have been employed. The limestone of Cockburn Island, in Georgian Bay, is used at Sault Ste. Marie. This stone belongs to the Niagara formation, and according to Mr. Sjostedt of the Lake Superior Power Company, possesses the composition given below. Analyses of other limestones used at Sault Ste. Marie, Ont., were also kindly furnished by Mr. Sjostedt. These are from quarries in Michigan, at Petoskey and Trout Lake and from Drummond Island:

	Dolomite (Cockburn I.)	Limestone (Petoskey)	Limestone (Trout L.)
	per cent.	per cent.	per cent.
Insoluble	1.5	1.0	.69
Iron and Alumina	3.5	2.0	.33
Cal. Carbonate	82.0	84.0	98.01
Mag. Carbonate	11.0	10.0	.85
Undetermined	2.0	3.0	....
	100	100	

	Dolomite (Drummond I.)
	Per cent.
Silica	4.33
Iron Peroxide and Alumina	4.14
Calc. Carbonate	51.18
Mag. "	39.38
Phosphorus	.224
Sulphur	.025

Silicate Brick

Sand and lime are fused or partly fused together in the manufacture of silicate bricks.

Smelting Ores

One of the most common and important uses of limestone is as a flux in the smelting of iron, lead, and other metals. The action of the lime reduces the metals, and the impurities in the ores, such as silica, are carried off in the slag.

Limestones carrying a high percentage of calcium carbonate are preferred for use as a flux, but as the analyses of limestones used at Hamilton, Midland and Deseronto show, Ontario blast furnaces do not all use such stone. Rock high in magnesia is often employed on account of the greater cost, in some localities, of the varieties higher in lime.

The percentage of phosphorus and sulphur in limestone used for blast furnace work has also to be considered.

Crystalline limestone from the town of Renfrew has been used in the smelting and refining operations at Sudbury.

The following interesting note on the stone used at the Hamilton Steel & Iron Company's plants has been furnished me by Mr. C. B. Fo., M.A., chemist and metallurgist to the company:

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(12) Thurston, Materials of Engineering, Part I., pp. 20-21.
(13) Ibid., p. 22.

"The stone we have been using in our blast furnace for several years is a dolomite, which is obtained from the mountain about five miles south of the city. An average analysis of this stone, for a considerable period, is:

	Per cent.
Silica	.75
Alumina and ferric oxide	1.00
Lime	30.24
Magnesia	20.18
Phosphorus	.021
Sulphur	.050

"In our steel works we use calcium carbonate for desulphurizing and removing the phosphorus from the steel in the open hearth process. This has an average analysis as follows:

	Per cent.
Silica	2.00
Alumina and ferric oxide	1.10
Lime	51.00
Magnesia	1.10
Phosphorus	.015
Sulphur	.05

"This calcite stone comes from the vicinity of Port Colborne, on Lake Erie, the nearest point to Hamilton at which calcite stone is found, all the limestone of our mountain being dolomite, with silica running from one-quarter of one per cent. up to six or eight. If the silica runs above three per cent. it hardly pays to use it here.

"It is generally conceded by blast furnace men that dolomite stone takes more fuel than calcite when used in a blast furnace, and calcite is generally supposed to be more efficient in the removal of sulphur. When smelting lean ores requiring a large amount of flux (i.e., where the proportion of ore to stone is lower than 3 to 1), the slag is liable to be dark and spongy, and difficult to handle when dolomite is used. On the other hand, it is claimed for dolomite that it prevents sticking and hanging in a furnace, and causes the stock to descend more easily.

"We have had samples of stone from a quarry at St. Mary's, which shows the stone there to be a calcite of about the same purity as that from Port Colborne. I suppose you have often seen this Port Colborne stone, as it contains a great amount of the fossil coral Columnaria alveolata, and these parts of the stone are usually highly impregnated with oil."

Analyses of the stone used in the blast furnaces at Midland and Deseronto will be found in the sections devoted to Simcoe and Addington counties respectively. The Port Colborne and St. Mary's limestones are described under the heading of Welland and Perth counties respectively. The stone which Mr. Fox says is used in the Hamilton blast furnace is quarried in Wentworth county.

Soda Manufacture

At the works of the Canadian Electro-Chemical Company, Sault Ste. Marie, caustic soda and bleaching powder have been produced during the last two years. The raw materials used are lime and common salt.

Whiting and Whitewash

Pure chalk is the material most commonly used for whiting, but certain varieties of marl have been substituted.

Lime, mixed with water to the proper consistency, plays the part of paint in white-washing. It tends to preserve wood and acts as a disinfectant.

Cements

Cement materials, or those substances which, unlike ordinary lime, are used in forming mortars that harden under water, fall naturally into three classes:—(1) Hydraulic lime, (2) hydraulic or natural rock cement, (3) Portland cement. To these can be added pozzuolana, a name which is used for mixtures of ground blast furnace slag and slaked lime. The name pozzuolana was originally applied to a tufaceous rock in Italy.

Hydraulic properties increase in quick-lime with the increase in the percentage of the clayey constituents. When these reach 8 or 10 per cent. hydraulicity begins to be developed. If 18 or 20 per cent. of these aluminous impurities are present the product, after burning, has to be ground fine before it will set.

All these cements owe their hydraulicity to the formation, while burning, of silicates and aluminates of lime and magnesia, which, together with calcic-hydrate, gradually crystallize and harden when exposed to water.

Hydraulic limes are made by burning limestones which contain about 20 per cent. of impurities, chiefly aluminium silicate. Fat limes are rendered hydraulic by the addition, as stated above, of certain rocks as pozzuolana and strass, or slag, burned clay and other materials, which contain silica and alumina in the proper state of combination.

Natural Rock Cement

Certain argillaceous limestones when burned possess the property of hardening under water, and are known as hydraulic limestones. One of the chief localities in the United States where such limestones occur is Rosendale, N. Y. Natural rock cement has been produced in large quantities here, and cements of this class are commonly known as Rosendale.

In Ontario limestones suitable for the production of natural rock cement are known to occur in several localities. The rock has been worked for many years at Thorold and at Nepean.

"In the Chazy formation, a bed of grey argillaceous magnesian limestone occurs a few feet above a blackish-brown band, which is marked by the shells of Leperditia. This magnesian layer, which weathers of a yellowish color, has a conchoidal fracture, and holds small geodes of calc-spar, may be traced by its mineral characters, and by the underlying fossiliferous bed, from Hawkesbury as far westward as Allumette Island. At Nepean, on the shore of the Ottawa, it has a thickness of 6 feet, and has for many years been quarried for the manufacture of a hydraulic cement. . . . .A specimen of the cement (produced from the rock at this place), gave to Delesse, lime 39.70, magnesia 9.58, soluble alumina and oxide of iron 19.74, insoluble argillaceous residue 30.98 ; 100.00. It is probable that this bed may yield a similar cement in other parts of its distribution. . . In the township of Lougborough, on the 1st lot of the 18th range, are beds which resemble that of the Chazy just described, and have been found to yield a hydraulic lime. A similar bed, 3 feet in thickness, occurs in the ditch around the fort at Kingston, and has been used as a cement. . . . .

"In the Niagara formation near Thorold, a band of dark grey argillaceous limestone, 8 feet in thickness, yields an excellent cement. Its color after calcination is yellow. A specimen examined by Delesse contained 3.37 per cent. of moisture, without any carbonic acid. Its farther analysis gave lime 53.55, magnesia 2.20, silica 29.88, alumina and oxyd of iron 12.70, sulphate of lime, 1.58 ; = 99.91. This cement was found to set in 10 to 15 minutes, with disengagement of heat. A portion placed in water 10 minutes after mixing became as solid as another portion which had set in the air, and was only immersed at the end of two hours. . . . . This cement has been largely used in the construction of many public works, and was employed in building the piers of the Victoria bridge. . . . . This layer of water lime does not appear to be continuous throughout the Niagara formation. At Limehouse, in Esquesing, there is a band of 9 feet, which is wrought to a considerable extent, and yields a good hydraulic lime. At Rockwood also a band of limestone three and a half feet thick, associated with a layer of chert, is said to yield a water-lime. The last two localities are in the Niagara formation, but are not supposed to be the equivalents of the Thorold stone." (14)

The Onondaga formation contains beds of argillaceous dolomites, associated with the gypsum deposits, which yield a hydraulic cement. "Analyses of this dolomite from Oneida and Paris are given below. The calcined rock from Oneida gave to Delesse, lime 36.93, magnesia 26.74, clay 36.33 ; 100.00. It heats very slightly when mixed with water, and yields a cement of good quality. The calcined material from Paris contained lime 53.82, magnesia 35.93, clay 10.25. A specimen from this formation, on the 14th lot of the 2nd range of Brantford, yielded a cement which hardened under water in the course of five minutes. Similar beds are found at Point Douglas on Lake Huron; and it is probable that the materials fit for the manufacture of water-cement may be found almost everywhere along the outcrop of the Onondaga formation." (15)

The manufacture of natural rock cement at Napanee Mills is referred to in later pages, under the section devoted to Addington county.

Analyses of limestones used in the manufacture of natural rock cement in Ontario and at a few important foreign localities are given in the following table :

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(14) G.S.C., 1863, p. 806.
(15) Ibid, p. 807.

	1	2	3	4	5	6	7	8	9
Calcium carbonate......	45.30	39.91	51.33	56.28	47.07	45.94	35.60	35.54	67.14
Magnesium "	12.77	34.15	40.91	20.07	30.32	26.11	19.26	32.16	2.90
Alumina and Ferric oxide......	12.52	......	......	2.20	2.71	11.38	4.81	1.11 13.03	7.49
Silica	......	......	......	......	......	15.37	33.80	17.56	18.34
Insol. argillaceous residue	19.77	22.10	5.50	20.90	19.64	......	......	......	......
Water and loss by ignition	9.64	3.84	2.26	.31	.20	1.20	6.82	......	3.94
Total	100.00	100.00	100.00	99.76	99.94	100.00	100.32	99.90	99.81

1. Nepean. 2. Oneida. 3. Paris. 4. John Brown's quarry, Thorold. 5. Alex. Manning's quarry, Thorold. 6. Rosendale, N.Y. 7. Akron, N.Y. 8. Milwaukee, Wis. 9. Coplay, Penn.

The quarries from which the rock used in the manufacture of natural rock cement is obtained at Thorold, Queenston, and Limehouse are described on pages 108-109 of the First Report of this Bureau.

It will be seen that the limestones from which natural rock cements are made are variable in composition. Unlike Portland cement, many of these cements, practically 90 per cent. in America, carry a comparatively high proportion of magnesia. Those containing little or no magnesia, if the percentage of argillaceous material be right, set more quickly, and are said to be the stronger cements. Such calcareous cements, in Europe, are known as Roman cements.

The kilns used in burning natural rock cement are similar to those used in burning ordinary lime. Care must be taken not to heat the cement to too high a temperature and thus bring about sintering. After burning the material is ground to a fine powder and sifted.

"The natural rock cement industry has been materially interfered with during late years by Portland cement. When the demand (for Portland cement) is completely supplied by American manufacturers, we shall have works in this country producing 2,000 barrels per day more than in Germany, and the same result will be reached here as in Germany, namely, the complete replacement of the common natural cement rock cements by artificial Portland." (16)

Portland Cement

A very rapid growth has been witnessed in the Portland cement industry in North America during the last 15 years. Judging from the prices at which cement is being sold at the present time, and from the general state of the industry, the output on this continent about equals the consumption. A few years ago prejudices existed against the use of domestic cement, and much of the supply was obtained from Europe. It has now been thoroughly proved that American cements are not inferior to any of the brands produced abroad. In some respects the industry has reached a higher state of development on this continent than elsewhere.

Portland cement was invented in England, receiving its name from its supposed resemblance to Portland stone. In general, this cement acts like ordinary natural rock cement, but being of a more definite chemical composition, it possesses superior physical properties, and is used for all the more important structural purposes. In Germany, as already stated, natural cement has practically been entirely replaced by Portland.

Portland cement is made from a mixture of clay and carbonate of lime. In this Province all the plants which have been in operation up to the present time use marl as their source of carbonate of lime. It is claimed that a saving in the cost of manufacture can be made by substituting solid limestone for marl, as is done in the great majority of the plants in New York State and elsewhere. It should be remembered, however, that many of these limestone are argillaceous, and thus do not require the addition of clay to the cement mixture, a small percentage of pure limestone being added to bring the mixture up to the right chemical composition. One or two plants which are to use limestone in place of marl are under construction in Ontario, as is also the plant at Hull, Que. The limestone to be used by these plants belongs to the Trenton group and is not argillaceous.

In Europe, where the cement industry has reached great proportions, chalk of suitable chemical composition is found in many places. By using it the cost of manufacture should be less than if either marl or limestone is employed.

Magnesia, in proportion above say 4 per cent. in the manufactured material, is carefully avoided in the production of cement. Although much attention has been paid to the subject, comparatively little is yet known as to the exact effects which magnesia has on cement.

The reader who desires details concerning the methods of manufacturing and character of Portland cement, as well as the means employed to test its quality, is referred to the numerous treatises on the subject which have been published during late years. It will suffice to state here that in the older processes of manufacture the materials were usually dried, ground together, and then moistened and moulded into bricks. These bricks were then calcined or burned to clinker, after which they were ground to a fine powder, which represents the cement as it comes into the market. Of late years the rotary kiln has replaced the older form. The materials, after being suitably ground and mixed, pass into a large inclined revolving tube. The materials entering at the upper end are subjected to a temperature high enough to produce clinker before, in their gradual passage through the tube, they emerge at the lower end. This clinker is then ground to a fine powder.

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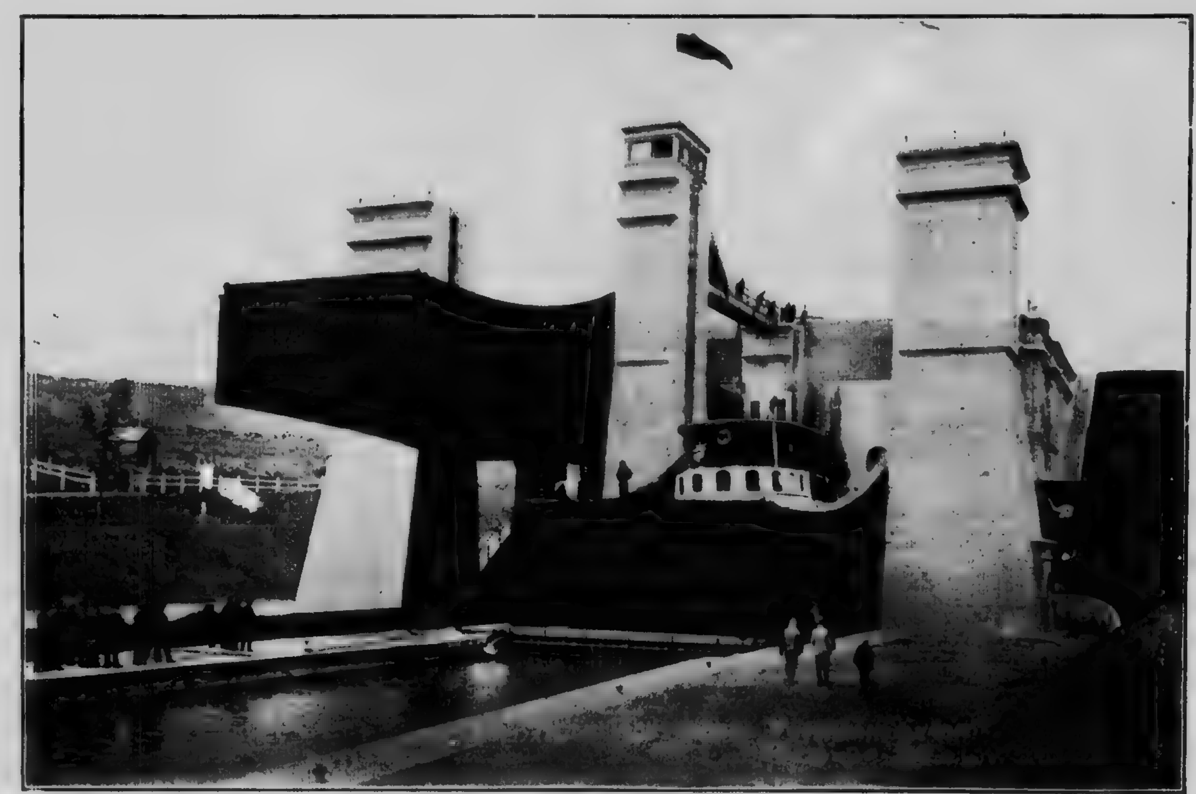
(16) S. B. Newberry, Brickbuilder, 1897, p. 108.

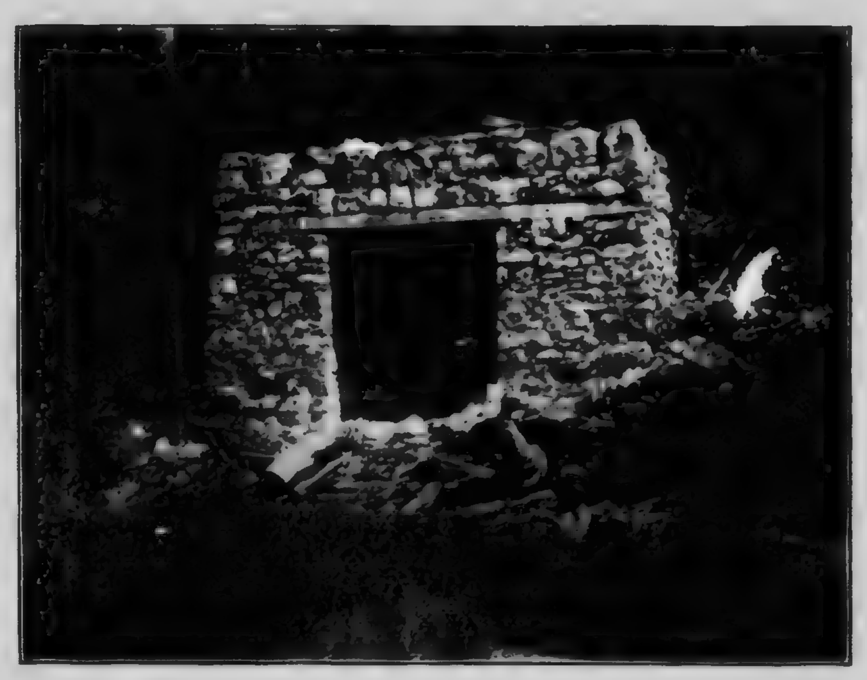


Hydraulic lift lock on Trent Canal, Peterborough, constructed mainly of cement ; 26,000 barrels cement used in concrete work ; substructure of lock said to be largest monolithic mass of concrete in the world.

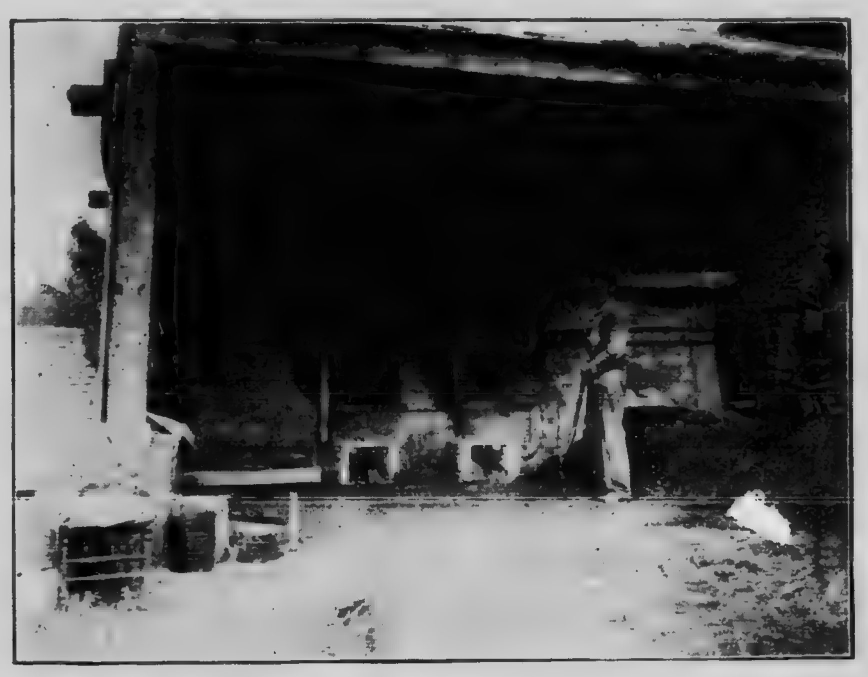
" Drawing " a lime kiln, showing freshly burned lime.

Top of loaded lime kiln being burned, Rockwood. Wellington County.

D. Robertson & Co's lime kilns, 2½ miles northwest of Milton. Limestone beds for burning only are in background on hillside. Halton County.



An ancient "set" kiln for burning field boulders; 10 feet high, inside measurement.



Lime kilns at Limehouse, showing double fire-door and forced-draught pipes. Halton County.

In the Twelfth Report of the Bureau of Mines a short account of the cement plants which were in operation in the Province in 1902 is given. The following extracts are taken from it:

Cement Making in Ontario.

"The manufacture of Portland cement in Ontario had its origin at Marlbank in the county of Hastings and at Shallow lake in the county of Grey, at nearly the same time about twelve years ago. The present centre of the industry is in the county of Grey, where six out of the nine producing plants are situated. A brief description of these and the other factories in the Province, and some account of the new establishments which appear likely to be manufacturing cement shortly, may be found of interest.

"The works of the Hanover Portland Cement Company, Limited, are situated at Hanover, Grey county. Its marl beds are a mile and a half distant, and its clay deposits close to the works. The plant consists of a brick factory, and brick and cement warehouses, and includes drying darres, wash mills, ball and tube mills, slurry grinding and pumping machinery, automatic carriers, etc. The kilns at present in use are five Bachelor set kilns and one Schneider continuous kiln. The capacity of the plant is 150 barrels per day, but the company has recently offered for sale $180,000 worth of 7 per cent. cumulative preferred stock—the total authorized capital being $500,000—with the proceeds of which it is proposed to increase the capacity to 650 barrels per day, construct a railway to the marl deposits, develop a water privilege on the Saugeen river for power purposes, and make other improvements. The company's brand of cement is the "Saugeen.' A siding connects the factory with the Grand Trunk Railway. D. Knechtel is president and J. S. Knechtel managing director.

"The Lakefield Portland Cement Company, Limited, began the construction of their plant at Lakefield in the county of Peterborough in 1900, and were manufacturing cement early in 1902. The works are situated on the Trent canal and were planned with a view of utilizing an all-water route for the transportation of cement to Montreal and lower ports. The whole of the machinery is operated by electric power derived from the Trent canal, which affords a large economy in fuel for power purposes. The completion of the canal would, it is estimated, enable the company to reduce its coal bill for cement burning to the extent of $15,000 per annum. Three kilns only were installed last year, but three more are now being added, which will give the plant a capacity of about 200,000 barrels per annum. The company's brand is "Monarch," and it has taken well in the market. J. M. Kilbourn is president of the company, F. A. Kilbourn, secretary-treasurer, and A. S. Butchart, superintendent.

"Manufacturing was begun at the Sun Portland Cement Company's works at Owen Sound in October of last year, the output up to 31st December being about 8,000 barrels. The site of the plant consists of about 4½ acres of land, lying between the bay at Owen Sound and the Grand Trunk Railway, with which line the works are connected by switches, and there is ample dock room for unloading and storing coal as well as for shipping cement. The manufacture is by the dry rotary kiln system. The buildings were erected with the view of producing 600 barrels of cement per day, but machinery for one-half this output only was installed. Additional facilities are being added to bring the capacity up to 500 barrels per day. The marl bed is at McNab lake in the township of Keppel, about 2½ miles from Shallow lake, where the company's railway connects with the Grand Trunk system. The marl is loaded on ordinary cars by means of a steam derrick, which will lift from the bed and place on the cars about 700 tons per day. These cars are hauled by the company's locomotive to the Grand Trunk at Shallow lake and thence to the mills by special G.T.R. trains. The clay beds are in the village of Brookholm, about three-quarters of a mile from the factory, to which it is at present delivered by team. Mr. James A. Cline is secretary and general manager of the company.

"The Owen Sound Portland Cement Company, Limited, has its works alongside of the marl deposit at Shallow lake on the Grand Trunk railway. The wet process of manufacture is employed. The power, mixing and grinding capacity of the plant is equal to 1,000 barrels per day, but the kilns now in use cannot put through more than 525 barrels. Rotary kilns are being added to place the burning facilities on a level with the rest of the plant. Mr. R. P. Butchart is manager of the company.

"Mr. M. Kennedy is president, and Mr. J. W. Maitland, secretary treasurer, of the Imperial Cement Company of Owen Sound, which has an authorized capital of $250,000. The works are situated at Owen Sound, and have a capacity of 300 barrels per day. The process used until last year was the dry system, but was changed to the "semi-wet," drying being done in rotary dryers, and burning in stationary Alborg kilns. Marl is procured from Williams lake, about fourteen miles from Owen Sound on the Canadian Pacific railway, and clay close to the works. The company's product is branded as "Imperial," and is marketed mainly in Ontario and Manitoba.

"Another plant at Owen Sound is that of the Grey & Bruce Cement Company, Limited, which began making cement in 1902. The capacity is about 200 barrels daily.

"The Canadian Portland Cement Company, Limited, whose head offices are at Deseronto, operates two factories, one at Marlbank and the other at Strathcona. In 1902 the capacity of the former was 600 barrels per day, but in the autumn the installation of additional kilns and machinery was begun to increase the capacity to 1,200 barrels per day, and the work will now shortly be completed. The raw materials are marl, of which there are large deposits at Dry and White lakes, and blue clay. In mixing the wet process is employed; in burning rotary kilns are used, and grinding the clinker is done in ball and tube mills. At the Strathcona plant, the capacity of which is 300 barrels per day, mixing is carried on by the wet process, burning by continuous shaft kilns, and grinding by ball and tube mills. This company's brand is the "Star," which is favorably known.

"The plant of the National Portland Cement Company, Limited, which began producing cement since the beginning of the present year, is situated at Durham, in the county of Grey. The marl beds are at Wilder's lake, some miles away, where the marl is raised by a steam dredge and placed in hopper cars on a line of railway connecting with the works. The rotary kiln system is employed, and the works have a capacity of 1,000 barrels per day.

"The factories mentioned in the foregoing paragraphs comprise all those which have been completed and are at the present time actually producing cement, but there are two or three more which are now in process of construction.

"Among these is the plant of the Raven Lake Portland Cement Company, Limited, which was incorporated in 1902, and the directors of which are: Hon. Geo. McHugh, Lindsay; J. H. Carnegie, M.P.P., Coboconk; John Lucas, Toronto; Thomas Christie, Toronto; Duncan Robertson, Toronto; W. Sargeant, Barrie; Thos. McLaughlin, Toronto. The last named is also secretary-treasurer, with offices at 16 King street west, Toronto. Raven lake is a sheet of water about 354 acres in extent, lying alongside the Coboconk branch of the Grand Trunk railway, about 1½ miles from Victoria Road station. The water is about one foot deep, and underlying it is a body of marl said to be from 10 to 20 feet in depth. The buildings which are now being erected will stand between the railway track and the lake. Four rotary kilns are to be installed at the outset, each 60 feet long, with a drying extension 40 feet in length, making a kiln practically 100 feet long. The output of these four kilns is expected to be 700 barrels every 24 hours. Provision is being made for an easy enlargement of the plant by installing additional kilns. The work is being done under the supervision of Mr. R. F. Wents, of Nazareth, Pennsylvania, who has had long experience in erecting cement factories. The buildings are to be fire-proof and of steel-frame construction. All machinery is to be operated by electric power generated at Elliott's Falls on the Gull river, some twelve miles away. Special features claimed for this undertaking are water power with dams already built, and proximity of marl supply and factory to the railway, thus obviating the expense of constructing and operating branch lines.

"The Ontario Portland Cement Company, Limited, is building a cement plant at Blue lake in the township of South Dumfries, where, and in the marshes surrounding the lake, there is a large deposit of marl. A siding from the Grand Trunk railway will run to the stock-house door, while the works themselves are within 75 feet of the marl bed. Clay underlies the marl. Manufacturing will be by the wet process, rotary kilns 70 feet long will be used for burning. The buildings are of brick with steel and iron roofs, and are being erected of size sufficient to allow of additional machinery being put in if required. At the outset the output will be about 500 barrels per day. The company, whose head office is at Brantford, has an authorized capital of $450,000. The officers are E. L. Goold, president; W. S. Wisner, vice-president; W. C. Elliott, managing director, and E. D. Taylor, secretary-treasurer.

"Hitherto all the Portland cement produced in Ontario has been made with shell marl as the ingredient supplying the necessary carbonate of lime. It is contended by some that where solid limestone can be obtained of the required chemical composition, it can be substituted for marl with advantage in economy of manfacture. The marl as it is raised from the beds of shallow lakes, where it is usually found, contains a great deal of water, which must be got rid of in the process of manufacture, and which adds to its weight and consequently to the expense of handling. Solid limestone on the other hand carries less moisture, and the crushing to which it requires to be subjected can be performed at less cost than is required for expelling the water from the marl.

"The Belleville Portland Cement Company has been organized to manufacture Portland cement from limestone and clay, by what is known as the dry rock process. Roughly speaking, this means the crushing of the limestone in large gyratory crushers, after which the clay is mixed with the rock in the proper proportions. The material then passes through the rock dryers, and the small amount of moisture driven off. It then passes to the rock pulverizing rooms, where it is reduced in Griffin mills to the fineness of flour. From this room it goes to the kilns to be dried or burned, issuing as clinker, which is then ground or pulverized to the proper degree of fineness for finished cement. The company's rock deposit is said to be of fine quality and to contain a very large quantity of raw material. It is entirely bare of covering. The clay beds lie close by, and the railway connecting the works with the Grand Trunk runs directly through them, so that the cost of hauling will be small. The equipment of the mill will be of the most modern type. Grinding machinery will be operated by direct connected engines, and the outlying portions of the plant by electricity. The buildings will be of stone with expanded metal and concrete roofs.

"The situation of the works will be on the Bay of Quinte, on lot 18 in the broken front concession of the township of Thurlow, within four miles of the city of Belleville, where the company will have two docks, each with fourteen feet of water, thus enabling the regular river and lake boats to load. One dock will be used for unloading coal from Oswego, and the other for the shipping of finished cement. The plant is to have ten rotary kilns, each being rated at 250 barrels per day of twenty-four hours, thus giving a daily output of 2,500 barrels. Limestone for making the cement will be taken from lots 16, 17, 18 and 19 of the broken front concession, Thurlow township, and clay from lot 14 in the first concession, about two miles from the works. The following analyses furnished by the company's engineer, Mr. C. B. English, show the composition of the limestone and clay:

Constituent.	Clay.	Limestone.
Silica	61.70	0.60
Alumina	16.60	0.78
Ferric oxide	5.20	
Lime	2.30	54.67
Magnesia	2.30	0.54

"The Colonial Portland Cement Company, Limited, has been formed with a capital of $800,000, of which $300,000 is 7 per cent. preferred and $500,000 common stock, to erect a 1,000-barrel mill on Colpoy's bay, near Wiarton, in the county of Grey. Mr. Elbert L. Buell, of Detroit, Mich., is president, and Mr. David A. Wright, Wiarton, is secretary. The beds of marl and clay are situated in the township of Keppel, close to the site of the proposed works."

Since the foregoing was written, the plants of the Raven Lake and Ontario Portland Cement companies have been completed, and are now (1904) turning out cement.

Origin and Nature of Limestones

Most rocks are mixtures of two or more minerals. Thus one of the best known rocks, granite, consists normally of a mixture of grains of quartz and feldspar together with mica or hornblende. The grains of these minerals can usually be distinguished by the unaided eye. A few rocks are glass-like in character, and cannot be considered as mixtures. Two or three rocks, while made up of grains, contain only one essential mineral, although others are usually present as accidental or accessory constituents. Limestone is one of these. It contains as an essential mineral calcite only. This mineral is composed of calcium carbonate, whose chemical formula is $CaCO_3$. The calcium oxide, CaO, commonly known as lime, makes up 56 per cent. of this compound, and the carbon dioxide or carbonic acid gas, CO_2, 44 per cent. Most persons who have little chemical knowledge and are not familiar with the characteristics of other rocks, are acquainted with some of the reactions of limestone. It is known that if this rock is strongly heated a product is derived which has properties quite different from the rock itself. And few there are who have not noticed that when a fragment of the pure rock is dropped into an acid solution, or when acid is applied to the surface of the rock, a gas is given off, or the specimen is said to effervesce—in the language of the prospector, the rock is said to "burn." It is well to remember, however, that this effeverescence is not a sure sign that the sample being tested is calcite or limestone, as other carbonates act in a like manner when similarly treated. It also should be borne in mind that certain magnesian limestones effervesce only in hot acid.

In the weathering or decaying of rocks by atmospheric agencies the lime contained in them goes into solution. It finally becomes a carbonate, and may be precipitated or deposited directly, or it may be taken up by animals. It is from the shells or hard parts of such animals that most limestone deposits have been formed, the shells at the death of the animals falling to the bottom of the bodies of water, lakes or seas, in which they lived. Through pressure and solution these shells are broken up, and many limestones which at one time were built up of the calcareous shells of animals now give little evidence of containing organic remains. It would seem, however, that some of the oldest, or crystalline limestones, had been formed by the direct precipitation of lime from solution without the intervention of life, unless we are to assert, more strongly than the direct evidence warrants, that life existed on the earth at the time the oldest of the sedimentary or fragmental rocks were laid down.

There are many varieties of limestone, depending on physical constitution and chemical composition. Instead of being composed of pure calcium carbonate, a limestone may have some of the calcium oxide replaced by magnesium oxide, which is a compound that plays a part similar to that of lime in nature. Limestones carrying a comparatively high percentage of magnesia are called dolomites. The characteristics and uses of these are described on other pages of this report. By the replacement of all the lime by magnesia the rocks pass into magnesite, which theoretically is the pure carbonate of magnesia.

Limestones may contain more or less clay, in which case the term argillaceous is applied to them. The peculiar properties possessed by limestones of this class are referred to under the section devoted to cement.

In form and structure limestones present as great a variety as they do in chemical composition. Usually they occur in solid beds or layers. In chalk, an important economic variety, the grains are loosely held together, while marl or bog lime occurs in a loose, earthy form.

Solid limestones vary in grain from very fine, e.g., lithographic stone, to coarse. Those which have been subjected to heat and pressure, or what is called in a general way metamorphic agencies, become more compact and brighter in appearance. They are then known as crystalline limestones. Varieties of these, which take a good polish and can be used for ornamental purposes, are called marble. Crystalline limestone is characteristic of our older or pre-Cambrian series, which occupy parts of the more broken and agriculturally less productive areas of eastern Ontario. They are less abundant in the more northern and western parts of the Province.

The limestones of the Province are widely distributed. They exhibit great variety in character and in age, being found associated with rocks of all ages, from the oldest crystallized representatives to the marls which are now in process of formation in our lakes and ponds.

Crystalline Limestones

Among the much disturbed and highly crystallized rocks of what is known as the Archaean or pre-Cambrian formations—those rocks which occupy the greater part of the surface of our more rugged regions—limestone is frequently found. It is in these cases crystalline, and commonly occurs in beds or layers which incline at an angle of considerable size from the horizontal. These limestones appear to have at one time formed a layer or covering, sometimes of considerable thickness, over the underlying rocks, and owing to disturbances produced by the shrinkage of the earth's crust they have been folded and squeezed. The upper parts of many of these folds have been worn away by agencies of decay; so that now in walking over a rock surface one often finds what appear to be several distinct bands of limestone separated by rocks of various kinds. These bands have at times been mistaken for several distinct beds. In the Grenville series, so named from the locality in Quebec where these rocks wer first studied, limestone is abundant. This series belongs to our oldest system, or what is known as the Laurentian. These rocks occupy a large territory in this Province, particularly in the eastern portion, in the counties of Hastings, Frontenac, Lanark and others. In the region lying north and west of lakes Huron and Superior crystalline limestone occurs more sparingly than farther to the southeast, and is associated with a system of rocks, later in age than the Laurentian, which are known as the Huronian.

Crystalline limestones are adapted to uses to which the ordinary unmetamorphosed rocks are put. Some varieties make handsome building stones. Others are burned, as at the town of Renfrew, for lime. Frequently, however, these rocks are too impure to be thus used on account of the association of numerour minerals with them. Interesting and beautiful crystals of various kinds are often found in limestones as a matrix. These rocks are at times veritable storehouses, and are much sought after by mineral collectors. The crystals are usually easily separated, owing to the softness of the rock mass or to the fact that the limestone is easily dissolved by acids, while the crystals may be unaffected by it. The following is a partial list of minerals which occur in the crystalline limestones of the Province: Amphibole, apatite, calcite, chlorite, chondrodite, corundum, dolomite, feldspar, galena, garnet, graphite, mica, molybdenite, pyrite, pyroxene, quartz, scapolite, serpentine, sphalerite, spinel, talc, titanite, vesuvianite, zircon. Some of these minerals occur in large quantities either in or closely associated with limestones. Among these we have in Ontario deposits of actinolite, apatite, galena, graphite, phlogophite mica, sphalerite and talc, which have been mined with success. In India the gem varieties of corundum, sapphire and ruby, occur in crystalline limestone. Some Ontario localities are noted for large and perfect crystals of other minerals in the above list. Serpentinous limestones at times take a good polish, and make beautiful decorative material. Many of the magnetite deposits of the eastern part of the Province have one or both walls of crystalline limestone.

The rock for which crystalline limestone is most apt to be mistaken is quartzite, such as occurs in the La Cloche hills on the north shore of lake Huron. These rocks can, however, be distinguished from each other by simple tests. Limestone is easily scratched by the knife, while quartzite is not. The latter rock does not effervesce in acids.

"The bluish-gray limestones, which have been mentioned as yielding good building materials in the upper formation, are the source of the greater part of the quicklime used on the Ottawa, whether for mortar, for potash making, or for agricultural purposes, and it does not seem to be universally known among the settlers that there are any other beds capable of yielding lime. Persons residing in the immediate vicinity of the white crystalline limestones have been known to send to the fossiliferous beds the distance of nine and ten miles, for years in succession, for their supply, without being aware that they might satisfy themselves at home. In collecting information in respect to the geographical distribution of the rocks, it was often found in white limestone districts that a settler would be acquainted with every small accidental patch of the blue limestone to be met with in the woods for some distance, while it had never occurred to him that there was anything worthy of remark in the crystalline rocks on his own ground; and one respectable farmer, who had given me useful information in regard to the run of the upper calcareous rocks, and regretted he had no limestone on his own lot, saying he would willingly reward any one who would discover it for him, would scarcely believe me in earnest when a bed of the white crystalline variety, which was in sight, was pointed out to him for limestone." (17)

Palaeozoic Limestones

In addition to the crystalline limestones which are found among the older and much disturbed Archæan rocks, there is in the Province another group of limestones which are of great economic importance. They are found among what are known as the Palæozoic formations. The term Palæozoic means "ancient life," and is applied to these rocks on account of the fact that they contain the oldest fossils or remains of animals and plants of any of our rocks. Among the Archæan, which literally means "old," no remains of this kind have been found. If they ever were present in these rocks, there would have been little chance of their being preserved, owing to the great heat and pressure to which the Arcaæan formations have been subjected.

The Palæozoic rocks in Ontario are sub-divided into three great groups, a lower and older, the Cambrian, a middle, Silurian, and an upper, the Devonian. These groups can be thus distinguished in the field.

The Cambrian and Silurian groups were first studied in a part of Wales, and the names are derived from sub-divisions of that ancient kingdom. The other group gets its name from Devonshire. It may also be stated for the benefit of the general reader that these groups are commonly known as systems. The Cambrian, Silurian and Devonian are again sub-divided into what are known as formations. While the systems contain rocks of various kinds—sandstones, shales and limestones—the formations are more in the nature of units. Thus one formation is composed essentially of beds or layers of limestone, while another may be made up chiefly of shale or of sandstones. The names given to the Palæozoic formations in the Province have been derived, with one of two exceptions, e.g., Guelph, from localities in New York State, where these rocks were first studied and described, most of the formations of that State stretching across into Ontario,

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(17) G. S. C., 1845-6, pp. 92-93.

The following table gives the subdivisions, in ascending order from the oldest to the youngest, which are usually made in the rocks of the Province :

	Recent and Glacial	Marls, clay, etc.
		Boulder clay, etc.
PALÆOZOIC	Devonian	Portage-Chemung
		Hamilton
		Corniferous
		Oriskany
	Silurian	Lower Helderberg
		Onondaga
		Guelph
		Niagara
		Clinton
		Medina
	Cambro-Silurian	Hudson River
		Utica
		Trenton
		Bird's Eye and Black River
		Chazy
		Calciferous
		Potsdam
	Cambrian	Animikie, etc.
ARCHÆAN	Huronian	Upper Huronian
		Lower Huronian
	Laurentian	Grenville, etc.

Several of the Palæozoic formations are important as sources of limestone and lime. The Chazy, Bird's Eye and Black River and Trenton afford limestone which is usually pretty pure calcium carbonate. The Corniferous formation yields a similarly pure lime. The Calciferous, Niagara, Guelph and Onondaga yield magnesian limestones. Some beds of the Hamilton are pure limestone.

The Palæozoic limestones of Ontario may be grouped according to their geographical distribution as follows : Lower Ottawa—Cambrian and Silurian; Lake Ontario and Georgian Bay—Silurian ; Lakes Erie and Huron—Devonian ; James Bay slope—Silurian and Devonian. Small detached areas or outliers are found at numerous points over the Archæan, e.g., in the northern parts of some of the eastern counties and on islands in lake Nipissing; important exposures of Niagara limestone are to be seen at the head of lake Temiskaming.

The accompanying sketch map shows the chief geological divisions in the older portions of Ontario, where the outcropping rocks are in large part limestones of varying age and composition.

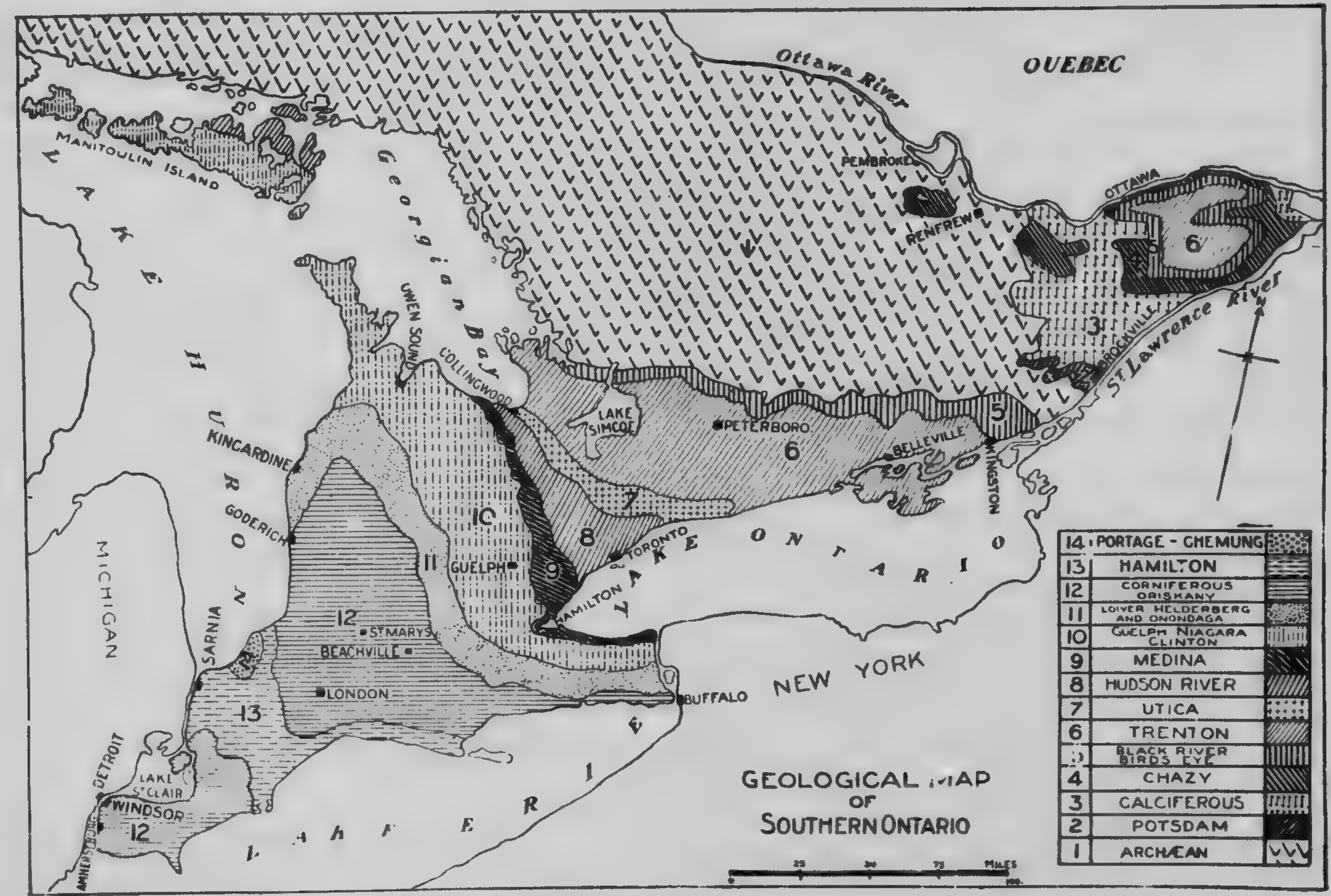
[illegible]tawa Area

This Pala[illegible]a is bounded on west by a lin[illegible]ch runs roughly from Brockville to the vicinity of the town of Perth, and thence to the Ottawa river, a little north of the mouth of the Madawaska river; its other boundaries are the Ottawa and St. Lawrence rivers. Detailed descriptions of the rock outcrops in this area are to be found in recent reports of Dr. R. W. Ells of the Geological Survey Department.

The limestone formations occurring here are the Calciferous, Chazy, Bird's Eye and Blac[illegible]iver, and Trenton. The first mention[illegible]s found in the counties of Leeds, Grenville, Lanark, Carleton and Russell. It consists chiefly of dolomitic and sandy lime[illegible]ones—frequently spoken of as "bastard [illegible]mestones.

L. Ontario—Georgian Bay Area

This Palæozoic area is separated from that of the lower Ottawa by the Archæan belt, which crosses the St. Lawrence river between Brockville and Kingston, and extends southward into the Adirondack region.


GEOLOGICAL MAP OF SOUTHERN ONTARIO

The Silurian strata, or beds, in this area show a slight dip towards the southwest. Hence in travelling over the land surface from the eastern to the western end of lake Ontario, we pass from the older to the newer formations. Outcrops of the Calciferous and Chazy have not been definitely observed in this area.

Kingston is known as the "limestone city" on account of so many of its prominent buildings being constructed of limestone, of the Bird's Eye and Black River formations, which afford excellent stone in numerous near-by quarries. The exposures of these formations extend northwestward to the Georgian bay and Manitoulin island, forming [illegible] southern boundary of the broken Archaean region of southeastern Ontario. Numerous quarries, which afford the best of stone for many structural purposes have been opened in these formations, e.g., at Crookston, Longford Mills and elsewhere. The rock usually carries a high percentage of calcium carbonate, and is thus well adapted for use in Portland cement, for lime, for the production of calcium acetate, for beet-root sugar purposes, etc.

The Silurian formations outcrop in the form of belts which run in a northern or northwestern direction, the western boundary of the area being formed by the Lower Helderberg, which runs from near the head of Niagara river to the shore of lake Huron, in the county of Bruce.

In chemical composition the limestones of the Bird's Eye and Black River are similar to those of the closely related Trenton. The southern part of this latter belt has its western boundary in the neighborhood of Newcastle, a few miles west of Port Hope. On the Georgian bay it outcrops in the territory lying between Collingwood and the mouth of the river Severn, along the northern edge of Manitoulin island and on some of the smaller islands in the North Channel.

The Trenton, and Bird's Eye and Black River belong to the Lower Silurian, or as it is sometimes called, the Ordovician. The limestone-producing formations of the Upper Silurian are the Clinton, Niagara, Guelph and Onondaga. They are characterized, in distinction from those of the Lower Silurian, by the presence of a considerable amount of magnesia. The Clinton formation, which has a thickness of 80 to 180 feet, is made up in its lower part essentially of shales of various colors, which are at times more or less ferruginous, and in its upper parts chiefly of dolomitic limestone. The "cement" manufactured at Thorold comes from this formation. The formation is well developed on Manitoulin island and at other points farther south. It forms the base of the escarpment at Hamilton and elsewhere; is underlaid by the Medina sandstone, and passes above into the Niagara limestone.

The Niagara formation enters the Province from New York state in the county of Lincoln, and extends northwestward to Cabot's head on lake Huron and to the Manitoulin island. At Hamilton and elsewhere throughout its course it forms the upper part of the escarpment, or "mountain," which forms such a striking feature in the topography.

The strata which are placed at the uppermost part of the Niagara in the neighboring States are in this Province grouped under the name of Guelph, after the town in the vicinity of which some of the best outcrops are found. The maximum thickness of this formation is about 160 feet. The greatest development of the formation is found in the counties of Grey, Wellington and Waterloo, but outcrops are found at various points from the Niagara river to the shore of lake Huron in the county of Bruce. Exposures on the southern side of Manitoulin island, at the mouth of South bay, have been provisionally called Guelph. The limestones of this formation are for the most part white or light-colored, and have usually a peculiar semi-crystalline or granular texture. All of the stone of this formation is magnesian. It affords excellent building material in many localities, and burns to a high-class lime.

The Onondaga formation enters Ontario from New York state a short distance above the falls on the Niagara river, and follows the general outcrop of the Guelph to the vicinity of the Saugeen river on lake Huron. Much of its surface is covered with recent deposits, but portions of the counties of Welland, Haldimand, Brant, Oxford, Waterloo, Perth and Bruce are underlaid by it, and in it the gypsum deposits in the vicinity of the town of Paris and elsewhere occur. The formation is made up of thin beds of magnesian limestone of light gray or yellowish color, together with greenish calcareo-argillaceous shales. Some of these shales furnish material suitable for the manufacture of hydraulic cement. The salt deposits of the Province are situated near the base of the formation.

The Lower Helderberg appears to extend as a thin band along the western border of the Onondaga from lake Erie to lake Huron. Exposures have been found only in the townships of Bertie and Cayuga. It here represents only a small portion of the New York state formation of the same name, and consists of thin bedded dolomites, or magnesian limestones, with interstratified shales and a brecciated bed, chiefly of dolomite fragments, at its base; the total thickness does not exceed fifty feet.

Devonian of L. Erie and Huron

It will be remembered that the limestones of the Lower Silurian and Cambrian, with the exception of those of the Calciferous formation, usually contain a high percentage of calcium carbonate, with little magnesia, while those of the Upper Silurian — the Clinton, Niagara, Guelph and Onondaga — are characterized by the presence of magnesia in considerable amount. This difference in chemical composition is doubtless due to the character of the sea water in which the limestones of the various formations were laid down. It is reasonable to infer that during Lower Silurian times the waters of the Palæozoic sea carried a comparatively small amount of matter in solution. As time went on evaporation took place, and there was a tendency for the salts of magnesia to be precipitated. Hence we find the calcium of the Upper Silurian limestones replaced to a greater extent by the closely related metal magnesium. At the time the Onondaga rocks were being formed the waters of the sea had become so concentrated that deposits of gypsum and even rock salt were precipitated.

During Devonian times the waters appear to have again become somewhat like what they were in the Lower Silurian period, owing to the depression of the land surface or to some other cause, and the Ontario Devonian limestones, those of the Corniferous and Hamilton formations, contain as little magnesia as those of the Cambro-Silurian period.

The Corniferous formation—from the Latin, cornu, a horn, so called from the nodules of hornstone which it frequently encloses—occupies two large areas, separated by a band of the succeeding Hamilton formation, in that part of the Erie and Huron peninsula which lies southwest of a line running from the mouth of the Grand river on lake Erie to the outlet of the Saugeen on lake Huron. The more eastern of these areas extends over portions of [illegible] counties of Welland, Haldimand, Norfolk, Brant, Oxford, Perth, Huron and Bruce. The shore of lake Erie from the head of the Niagara river to Port Rowan lies upon the formation, but in some localities exposures are few on account of deposits of glacial and recent age. The western area occupies parts of Essex, Kent and Lambton counties.

The limestones of this formation show a considerable variety. In some localities, e. g., at the town of Hagersville, they contain nodules of flint or hornstone, which unfits them for the manufacture of lime, but makes them adapted for use as road material. At St. Mary's, Beachville and Amherstburg they produce when burned a very pure lime which is used in the beet sugar industry and for other purposes. Good building and dimension stone has been quarried from the outcrops of this formation at numerous points; stone from the Amherstburg quarry, for instance, has been used in the construction of some of the canal locks at Sault Ste. Marie.

The Corniferous is also of interest on account of its being the storehouse of the petroleum of the region.

The Hamilton formation, so named from the town of Hamilton in New York state, and not as has sometimes been erroneously supposed, from the city of that name in Ontario, succeeds the Corniferous in ascending order. It consists mainly of soft calcareous shales, associated with which are a few beds of limestone. It extends across the counties of Norfolk, Elgin, Kent, Middlesex and Lambton and the south part of Huron. The limestone beds seldom outcrop at the surface. Those in the vicinity of Thedford and Stoney Point, on lake Huron, have been found to carry a high percentage of calcium carbonate.

The sketch map shows the relative position of the limestone-bearing formations which have been described, as well as those of other character—Potsdam sandstone, Utica and Hudson river shales, Medina sandstone, and Oriskany sandstone—which come in at various points in the series from the base of the Ordovician to the top of the Ontario Devonian.

Northern Palæozoic Area

In the imperfectly explored region north of the height of land and tributray to James bay, limestone strata of Upper Silurian and Devonian age are known to occur. Much of the surface is low and drift-covered, and outcrops of solid rock over a large part of the district are not numerous. Dr. Robert Bell, who has explored the region, says "The most northerly section of Ontario, or that bordering on the lower part of the Albany river and James bay resembles the most southerly portion, or the peninsula between lake Huron and the lower lakes, in being underlaid by almost flat-lying Silurian and Devonian rocks, while the great intermediate tract is occupied by a part of the great Archæan area which stretches to the Arctic regions." Outcrops which appear to belong to the

Niagara, Guelph and Corniferous formations have been observed in the area to the south and west of James bay. These will be referred to again in the section dealing with counties and districts.

In the Archæan region, lying between the older settled parts of the Province and the level territory to the north of the height of land small areas or outliers of the Palæozoic strata have been discovered, such as that at the head of lake Temiskaming which has been already mentioned. These, though of small size, may, like the one just mentioned, be of economic importance in the future.

From what has been said, it will be seen that the youngest of the rocks lying in the region north of the height of land, with the exception of glacial and recent deposits, are of Devonian age. Hence no true coal or coal-bearing rocks, namely, the Carboniferous, are to be found there. There is no known reason, however, why oil-bearing strata, such as those of southwestern Ontario, should not be looked for in this northern Devonian.

Limestones of Recent Age

In a geological sense a rock is a substance which makes up an important part of the earth's crust. In form it may be solid or loose. Hence marl, or bog lime, as it has recently been named, can be classified with limestone. Marls in many cases contain a high percentage of calcium carbonate, and thus resemble in chemical composition some of the older limestones of the Province, such as those of the Trenton and Corniferous formations.

During recent years marls have been much sought after for use in the manufacture of Portland cement, on account of their purity and comparative freedom from magnesia. Now that the chemical composition of the older solid limestones is better known, cement works have begun to use them, in preference to marl. It is claimed that it costs less to grind a solid limestone to powder and get it into form resembling dried marl, than it does to extract the water which forms a high percentage of the latter. Marls are adapted for use in many other processes to which solid limestones are put.

Beds of it are widely distributed throughout the Province, and occurrences will be mentioned under the next heading.

Marl is formed usually in small bodies of water by the deposition at the death of small organisms of their calcareous shells, which organisms have their habitat in lakes and ponds, and by the precipitation of calcium carbonate from solution. While this precipitation may be due to some extent to inorganic agencies, it is believed that minute organisms play an important part in the process.—(Geol. Sur. Mich. Vol. VIII., part 3, p 41.)

Limestone Occurrences by Localities

In preceding pages a brief description has been given of the general distribution of limestones throughout the Province. We shall now take up the occurrences by counties and districts. Mention will be made of important outcrops and quarries, and analyses of samples will be given. Although the writer has visited many outcrops and collected numerous samples for analysis, the time at his disposal has been too limited for him to gain, at first hand, all the information he could have wished. Free use has been made of the reports of the Geological Survey and papers by other workers. The counties and districts are arranged in alphabetical order.

It will be found in the following pages that the description of the limestones of one county will frequently apply to those of adjoining counties. Hence in searching for information on Frontenac county, for example, it will be well to look up the descriptions of Leeds, Lennox and the other counties which adjoin it.

Addington and Lennox

Limestones of two ages, Laurentian and Cambro-Silurian, are of economic importance in these united counties. The Marlbank marl deposits, of recent age, which have been used extensively in the production of Portland cement, are a short distance beyond the boundary of the counties, in Hungerford township, Hastings county. The cement plant at Strathcona, formerly Napanee Mills, which is the oldest of the kind (Portland) in Canada, uses this Hungerford marl.

The southern part of the counties for a considerable distance north of lake Ontario, is underlaid by Trenton limestone, under which we group not only the Trenton proper, but also the closely allied Black River and Bird's Eye formation. The contact between these formations and the Laurentian area to the northeastward follows a line which runs roughly from Frontenac county past Mud lake to Centreville in Camden, and thence northward by Tamworth and Beaver lake to Clare river. "Where the line between the third and fourth ranges of Sheffield comes upon Clare river, there occurs the greatest thickness of the beds observed in one mass in this part [of the counties.] It presents a cliff of about 40 feet. . . while on the same bank of the river, within seventy yards, the rock is gneiss" (18). Further notes on the distribution of the Silurian rocks in these counties are given in the descriptions of the adjoining counties of Frontenac and Hastings. The analyses quoted in these descriptions show the characteristic chemical composition of the Trenton rocks.

"Further west, Amherst island and the whole of the peninsula of Prince Edward county, are apparently entirely occupied by the Trenton formation, which abounds with fossils everywhere.

"The Black River formation, seen at Kingston, continues westward along the shore of lake Ontario as far the village of Bath, where it is overlaid by the Trenton limestone. The latter thence extends across the peninsula of Adolphustown to Deseronto, where the basal beds holding Receptaculites are seen in the bed of Sucker creek about half a mile south of the Grand Trunk railway near Deseronto junction. The outline of the formation north of this is somewhat irregular, and the Trenton limestone occupies basin-shaped areas upon the Black River to the north of Napanee, whence it extends northwest into Tyendenaga township. The Black River limestone shows in a bold escarpment on the west line of the township of Richmond, about six and a-half miles north of the Bay of Quinte, and a short distance south of the crossing of the Salmon river, whence the southern boundary of the formation continues southeasterly to the shore of the bay. The rocks are well exposed near Shannonville station on the Grand Trunk railway, where there is a boss of granite and quartzite upon which the newer limestone is deposited. The Black River limestone forms the north side of the Bay of Quinte at Ox Point, about three miles east of Belleville, and large and valuable quarries are here located in the massive beds near the summit of the formation. The opposite shore in Prince Edward county, at Massasauga Point, is of Trenton limestone. At Ox Point the strata are, in places, inclined at an angle of ten to fifteen degrees, probably indicating an underlying boss of the crystalline rocks.

"The Trenton comes in to view west of this place in a cove, and is again seen at Belleville on the Moira river, and northward along this stream for several miles, the exact contact with the Black River formation not yet being traced in this direction. From the Moira river the Trenton continues along the north side of the Bay of Quinte, and is well seen in low-lying ledges in rear of the town of Trenton, which is just beyond the western limit of map-sheet No. 112." (19)

The following table of analyses of Trenton limestone was kindly furnished by Mr. H. C. Mabee, chemist to the Deseronto Iron Company. Mr. Mabee states that the limestone used as a flux in the furnace comes from cuttings along the Bay of Quinte railway, between Strathcona and Yarker. The samples, the analyses of which are given in the table, from along the railway thus represent a pretty complete, approximately east and west, line across the township

Locality	$CaCO_3$	$MgCO_3$	Insoluble Silicious	Al_2O_3 Fe_2O_3	Phos.	Sulph.
Samples from yard, Deseronto Iron Co'y	91.014	.98	4.78	1.58	.....	.147
" south of Yarker	92.4	.88	5.10	1.22	.084	.21
" " on B.Q. Ry	87.77	3.74	3.73	2.76	.02	.074
" " "	89.50	2.09	4.50	2.07		.063
" " "	89.26	8.03	6.07	1.55	.009	.107
" " "	91.44	3.50	3.97	1.91	.002	.078
" " "	90.07	1.73	4.81	2.78	.013	.104
" " "	88.21	4.26	4.89	1.18	......	.063
" " surface shale	78.93	3.75	9.31	7.08	......	......
Sample from Point Ann, near Belleville	88.746	4.13	3.88	1.80	......	.159
" quarry at Newburg	93.3		5.00	.701	.15	.11
" Bath cut, B.Q. Ry	95.7		1.98	1.00	.06	.14

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(18) G.S.C., 1863, p. 179.

(19) G.S.C., Sum. Report, 1901, pp. 177, 178.

of Camden. Some of the analyses are of samples only, and not shipments, as the phosphorus and sulphur are present in too high percentages to make the stone suitable for blast furnace work. The silica also occasionally runs too high. The analysis of the Point Ann rock seems to represent a poor variety, judging from other analyses, with which the writer has been furnished, and which will be found under the heading devoted to Hastings county.

These samples represent for the most part picked material—material suitable for use in the blast furnace.

The following is the result of an analysis made of a sample of stone from Rollins' Hill, Napanee:

Silica..............	1.44
Ferric oxide and alumina	1.68
Lime	53.82
Magnesia......	.98
Carbon dioxide	42.40
	100.32

"At Napanee Mills we own a quarry in connection with our cement mills (natural rock cement). As far as we have worked yet we find that there are five or six layers of good cement stone, the aggregate thickness of which would be about four feet, the layers being separated from one another by layers of limestone. The cement stone commences, perhaps about two feet from the surface. We commenced work there about ten years ago. In connection with the cement works we employ about 30 men as regulated by the demand. Some parts of the work are going on constantly, such as the taking out of the rock, burning or grinding. The rock is broken to a uniform size, and then put into the kiln and burned; it next passes through the crushers and grinders, and finally through screens of a certain mesh, when it is fit for the market. Our output last year was about 9,000 barrels, valued at as many dollars. The market is in Ontario, to the Grand Trunk Railway Company, for public works, etc. Our capacity is equal to 400 or 500 barrels a day. There is no doubt that the cement is first class, for by actual test it stands ahead of the Akron cement. It sets as hard, but not as quickly, as the Portland. The demand for it is increasing; it works well with our terra cotta, making a firm and solid wall by the cement rooting into the porous character of the terra cotta material. We expect it will come more and more into use. Our contracts for 1889 aggregate already three times the output of 1888." (20)

White dolomite (crystalline limestone) from lot 1 in the sixth concession of the township of Sheffield is thus described: (21)

"Its cleavage faces present diagonal striæ. The specific gravity of this rock is 2.684, and it contains a very little quartz and mica.

	Per Cent.
Carbonate of lime....	52.57
Carbonate of magnesia......	45.97
Ferric oxide....	0.24
Insoluble, quartz, etc.........	0.60
	99.38"

Marl

Marl occurs on lots 15 and 16 of the second concession of the township of Sheffield. "The deposit extends over an area of two hundred acres, and perhaps more, with a thickness over the greater portion of at least ten feet.

"The air-dried material is earthy, friable; color, light gray. It contains numerous shells; also some wood-fibres.

"Its analysis afforded Mr. F. G. Wait the following results: (After drying at 100 degrees C.—Hygroscopic water, equal to 0.82 per cent.)

Lime....	51.97
Magnesia....	0.36
Alumina....	0.03
Ferric oxide...	0.09
Potassa...	traces
Soda...	0.08
Carbonic acid...	41.34
Sulphuric acid.....	0.03
Phosphoric acid....	0.02
Silica, soluble...	0.03
Insoluble mineral matter... ...	0.71
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water...	5.96
	100.62

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 92.80 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of (22)

Silica	0.48
Alumina and ferric oxide..	0.13
Lime.....	0.03
Magnesia.....	0.02
Alkalies.(?)........	0.05
	0.71"

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(20) E. W. Rathbun in Roy. Com., 1890, p. 84.

(21) G.S.C., 1863, pp. 592-3.

(22) G.S.C., 1894, pp. 25-26 R.

Algoma District

Crystalline limestones have been found at a number of points in this district. Doubtless some of these are adapted to use in certain metallurgical operations and for other purposes. Certain varieties are said to take a good polish, and can be classed as marble.

The Silurian limestones, which occur on the islands along the north shore of the Georgian bay are described under the heading devoted to Manitoulin island. (23)

Marls are found at numerous points in the district, but have as yet received little attention.

Geneva Lake

"In Geneva lake, about a mile and a half northeast of the outlet, there is an islet entirely composed of thinly-bedded light gray, dove-colored and nearly white dolomite, striking north 35 degrees east, and dipping to the westward side at an angle of 80 degrees. It is compact, and has a conchoidal fracture, but is traversed by fine threads of quartz, which prevent it from taking a good polish, otherwise it might be suitable for marble. The same rock is exposed on the east side of the lake on the point just southward of the above islet, but the band could not be found on the northern side of the lake, towards which it strikes in the opposite direction. On the railway track three-quarters of a mile south of the outlet of Geneva lake there is a fifteen-feet bed of gray to dove-colored fine-grained dolomite, weathering dark brown. It strikes north 45 degrees east, and the bedding is about vertical. This dolomite band is separated from hornblende granite to the southeast by about three hundred feet of ash-gray greywacke. The granite towards its contact with the latter becomes mixed with coarse breccia and conglomerate. On the other side, or to the northwestward, the dolomite is followed by coarse felspathic sandstone and silicious greywacke-conglomerate or breccia. At the outlet of Geneva lake the rock is a greywacke passing into granite, and it includes some black slate and a patch thirty feet thick of impure dolomite." (24)

A specimen of fine-grained crystalline limestone collected by the writer on the line of the Canadian Pacific railway near Geneva lake station, was found to possess the following composition: (24).

	Per cent.
Silica...	6.04
Alumina........	0.28
Ferrous oxide...	2.31
Lime...	27.01
Magnesia...	19.03
Carbonic acid....	41.87
Moisture...	0.16

Lake Panache

"Impure magnesian limestones are found at several places along the northern side of Lake Panache. They are generally fine-grained and semi-crystalline, of light greyish colors, and always contain a large proportion of silica, in the form of grains and threads or strings. The purer of two specimens from the north shore of this lake, analyzed by Dr. T. S. Hunt, gave 55.10 per cent. of carbonate of lime, and 6.5 per cent. of carbonate of magnesia, the balance being insoluble matter. The exposures of limestone on this lake do not all appear to belong to one band; indeed, they may constitute a number of great masses, wholly or partly formed by a process of segregation or concretion and may be unconnected with each other. At one part of the shore, where the limestone is well exposed, Mr. Murray estimated its thickness to be 150 feet. A band of impure light greenish-gray dolomite, weathering brown, crosses the Wahnapitae river at Island Portage, about three miles below the outlet of the lake. The rocks are here nearly vertical, but undulate a good deal, and I estimated this band to have a thickness of at least 300 feet. The rocks around L. Panache and thence by the canoe route to lake Wahnapitae are described by Mr. Murray in the Geological Survey Report for 1853-56, pages 178-190" (25).

Referring to the magnesian limestones of lake Panache, Mr. Alexander Murray says:

"On the north shore of Lake Panache, about midway between the inlet from lake Lavase and its western extremity, a band of limestone occurs which where first observed appears to be both underlaid and overlaid by syenitic slate-conglomerate. The mass of this limestone, which measures about sixty yards across and may be about 150 feet thick, is of a pale gray color on fracture, weathering to a bluish gray, with thin layers, which have the appearance of chert, but are in reality only harder portions of the limestone, weathering quite black. About the base of the calcareous strata some of the beds are blue, holding more silicious matter than the gray beds, while others are of a brecciated character. The beds are all more or less intersected by small veins of fine greenish jaspery-looking trap, which weathers brown or yellowish.

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(23) The following may be added: "South from Collins' inlent there are two groups, called the Fox islands and the Papoose islands; the former about 3, and the latter about 7 miles from the general run of the coast. On Bayfield's chart they are described as being composed of limestone." G.S.C., 1863, p. 193.

(24) B.M., Vol. I., p. 82.

(24) B. M. Vol. 12, p. 30.

(25) G.S.C., Vol. V., part 1, 1890-91, pp. 13-14 F.

"To the eastward of this exposure the only indications observed of the presence of limestone were on the east side of the large island at the entrance of the south bay, and in the peninsula on the north side at the entrance of the eastern arm; in both of these localities small exposures of a black-weathering brecciated rock, which proved to be calcareous, came up in one or two parts just over the surface of the water. On the island the calcareous rock is overlaid by a black-weathering slate, which, though without pebbles, resembles the matrix of portions of the slate-conglomerate. On the peninsula at the eastern arm the brecciated rock comes directly in contact with greenstone. . .

"At the head of the lower south expansion of Lake Panache the limestones are again seen on both sides, and also on the two islands near the middle, striking about east by north and west by south, and showing a southerly dip on the north side of the exposures; but the slate conglomerate with which it seemed to be associated at other parts only appears on the south side of the large island lying at the entrance to the northern arm, and between this island and the exposure of limestone on the west side of the bay there is a point to the north-east of the limestone displaying fine-grained green slate, which, though very much disturbed and intersected by quartz veins, appears to show a general dip to the northwest." (26).

Mr. Murray thinks that some of the above strata might yield good stone for burning into lime. A specimen from the section on the north side of lake Panache was analyzed by Dr. T. Sterry Hunt, and gave in 100 parts 55.10 carbonate of lime, 6.50 carbonate of magnesia, 38.40 insoluble sand and a trace of iron. A specimen of the limestone at the lower end of lake Panache, analyzed by the same chemist, gave 41.97 per cent. carbonate of lime, 2.40 carbonate of magnesia and 55.63 insoluble residue; and a specimen from the lower lake near the outlet, lying between the two ridges of the mountain range, gave 36.50 per cent. carbonate of lime with a little magnesia.

La Cloche Lake

"Along the northern arm of the larger La Cloche lake calcareous rocks or impure limestones occur at several places, passing below a considerable thickness of slate conglomerate, and they are again met with on the smaller lake to the northwest. High ridges of quartzite, standing nearly on edge and forming part of the La Cloche mountains, rise on either side of the southern arm of the larger lake, while greenstone and quartzite are found on the northern side of the smaller one. It would therefore appear that in this part of the great Huronian belt the magnesian limestones occur among the quartzites, and are sometimes more immediately associated with slate-conglomerate.

Township of Rutherford

"A band of finely crystalline limestone occurs among the Huronian rocks in the northern part of the township of Rutherford. The locality is near the boundary line between the red granite to the southward and a great thickness of quartzites to the northward. The junction of the granite to the southeast with the Huronian quartzite and hornblende schists to the northwest occurs at the south side of a rather elevated rocky island in a cove about one mile north of the western entrance to 'the passage' or channel, on the north side of which Killarney village is built. The geology of this locality and the relations of the limestone referred to can best be given by quoting the description in the Geological Survey Report by the writer [Dr. Robert Bell] for 1876, page 209:

"'On the west side of the township of Rutherford, from the northern limit of the granite (at the elevated rocky island above-mentioned) quartzites and hornblende schists hold the shore as far as Lamorandiere bay, in the northwest corner of the township. A blackish-green, massive and rather coarsely crystalline hornblende-rock, having an exceedingly rough or irregularly pitted surface, is exposed on either side of the narrow entrance to this bay. Upon the slope of the hill, about 100 yards in from the north shore of the bay, at a point about half a mile from the above-named narrows, a band of finely-crystalline limestone occurs among the Huronian rocks. It has a vertical attitude and runs about north 70 degrees west at the part examined. Its total thickness is about 75 feet, of which the 25 feet along the northern side consists of a single solid band of nearly white finely crystalline limestone, clouded with light greenish and grayish patches. The remaining 50 feet are mixed with shaly patches of hornblende, together with a little shining granular magnetic iron ore. Adjoining the limestone on the north side is a band, only a few feet in thickness, of dark smoke-colored chert-rock, ribboned with streaks of a dull red color. It breaks easily with a fine conchoidal fracture, and appears to be identical with a rock which was used by the mound-builders for making some of their arrow-heads. This is followed to the northward by a dark-colored dioritic conglomerate, in which the pebbles are mostly small and generally widely scattered, and farther on by a very dark gray, soft, massive-looking micaceous schist, most of which is full of small pebbles. Measured from the limestone band, a thickness of between 100 and 200 feet of these rocks is exposed.

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(26) G.S.C., 1853-54-55-56, pp. 181-183.

"'On the north shore of Lamorandiere bay, a few hundred yards eastward from the outcrop of limestone above described, are two exposures of very tough massive hornblende rock, and between the two arms of the bay is a more fissile variety, interstratified with a reddish gray quartzite, which also overlies the mixed rocks. The dip is here northwestward, at an angle of 60 to 70 degrees, and the series is underlain by granitoid gneiss.'" (27)

A sample of this crystalline limestone collected by the writer was found to have the following composition:

	Per cent.
Lime...	29.30
Magnesia...	19.00
Ferric oxide...	1.77
Alumina.	.37
Carbon dioxide...	43.00
Insol. residue...	6.94
	100.41

Marbles

"At Garden River, near Sault Ste. Marie, the Commission visited the quarries of the Warmington Stone & Marble Co. Here we found a mountain of marble, stated by the owners to be 5,000 feet wide, 8,000 feet long, 600 feet high and of unknown depth, while the band upon which these quarries are situated is supposed to extend inland for about thirty miles." (28)

"At Garden river they are opening a quarry of beautiful dark marble, a Huronian limestone or dolomite. The Garden river band extends for many miles; it crosses Echo lake, and has been traced and mapped through that country by Sir William Logan. I do not think it is uniform in character; in one place I think the beds would be better than in others. It seems to be a very beautiful and good marble, and the openings of Garden river I consider look exceedingly promising. Wherever the Laurentian limestones occur we can quarry them for marble, but they are generally coarse in the grain. I have not seen the marble at Bridgewater, but suppose it is the ordinary Laurentian crystalline limestone. I have seen some specimens that were brought from the township of Barrie. The marble there is coarse-grained, and has specks of quartz and other minerals in it. I have seen the Arnprior marble, and think there should be no difficulty in quarrying it. Some of that marble is very beautiful. It has already been extensively used, and its value proved. All limestones capable of taking a polish are marbles." (29)

"Half-way down Echo lake, on the north side, a point of banded marble runs out. It is composed in places of alternate thin bands of pure white and colored stone, much twisted. The colored portions being harder are weathered out more prominently, and show the structure very plainly. Sir William Logan describes its appearance very fully in his report on this district. As a rule the marble is tinted. This is especially the case behind Garden River, where the same series of marbles are again tapped; but at Echo lake there is an immense quantity of the banded marble with pure white streaks. Where again accessible in the bluff about two miles north of Garden River village, on St. Mary river, the band is about a mile wide. The strike is about east and west, and the dip about 50 degrees north. The marble is quarried at this location by a Chicago company, and a railroad is being constructed into it from the river. It is a very close-grained and hard stone, and is said to take an excellent polish. The colors are shades of green and pink in different parts of the bed, blending by very soft gradations into white. It is quarried against the north and south joints, and may be got out in very large layers." (30)

Palaeozoic Limestones

"In the northern part of the Province, west of James bay, we meet with almost horizontal gray and yellowish-gray limestones, containing fossils, which, according to the late Mr. E. Billings, the celebrated palaeontologist, belong to the Niagara formation. These strata occur along the Albany river above its junction with the Kenogami, and also along the latter stream as far up as the first portage. The limestones are overlaid by a considerable thickness of chocolate-colored marls with greenish layers and patches, but without observed fossils." (31)

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(27) B.M., Vol. I., p. 83.

(28) Roy. Com., 1890, pp. 228-229.

(29) Ibid, pp. 68-69; extract from evidence of Dr. Selwyn.

(30) Ibid, p. 76.

"On Moose river, banks of gypsum occur from ten to twenty feet high, especially on the northwest side below the junction of the Missinaibi, for a space of about seven miles, or from thirty-one up to thirty-eight miles above Moose Factory. About ten feet of the lower part of the deposit consist of solid gypsum of a light bluish-grey color, but the upper portions are mixed with marl. In some sections of these banks a comparatively small proportion of the gypsum, but still large commercially speaking, is nearly white, and from this circumstance they have received the name of 'the white banks.' The geological age of these deposits cannot be far from the Onondaga formation, and it would not be surprising if salt should also be found in the rocks with which they are associated." (32)

"In the region south-west of James Bay the Corniferous formation occupies an area greater than all the western peninsula of Ontario. A large part of this, lying between the Albany river and the basin of the Moose river, comes within the northern part of the Province. It consists mostly of porous and cavernous drab grey and yellowish grey fossiliferous limestones, resting directly upon the Archaean rocks to the southward, the line of junction cutting the Missinaibi river just below Hell-gate, the Mattagami just below the long Portage, and the Abittibi just below The Otters' portage. Many of the Corniferous fossils of this district belong to species which differ from those of the formation in regions to the south of the height of land, tending to show that there was here a separate basin in these early times, as well as now. At the foot of Grand rapid, on the Mattagami river the writer, in 1875, discovered a large deposit of rich clay-ironstone in these rocks. The materials of the drift, for a considerable distance to the southward of the Corniferous formation in this region, contain fragments of this ore, indicating that it exists, and probably in the same horizon, among these rocks, in many other places besides the above mentioned locality on the Mattagami." (33)

"The last exposure of gneiss is seen about three-quarters of a mile below the lowest portage [on the Kenogami or English river] or nearly 70 miles from Long lake, following the river, and the first exposure belonging to the great continuous area of unaltered flat-lying strata is about one and three-quarter miles farther down. This consists of a thinly bedded, greenish-drab, soft, fine-grained calcareo-argillaceous sandstone, without observed fossils. Between this point and Pembina island the strata exposed in the bed of the river consist of thinly-bedded, yellowish and drab-colored argillaceous limestones and shales. In the bank just above Pembina island a section of about 20 feet consists of soft-greenish-drab, earthy and porous, argillaceous beds, from 6 to 8 inches thick; underlaid by a few feet of yellowish-drab and bright brownish-yellow calcareous beds, having a conchoidal fracture, and measuring from 2 to 5 inches in thickness. These strata are as nearly as possible horizontal. They appear to hold no fossils." Fossils found in the gravel and shingle near by indicate that the strata are Upper Silurian, and probably belong to the Niagara formation. (34)

"Leaving the foot of the Long Portage, the first exposure of solid rock,—which is also the principal one on the river [Mattagami]—begins at 17 miles, or at the head of the Grand Rapid, which is about a mile and a quarter long, and has a fall of about 20 feet. On the northern side of the river, at the head of the rapid, there is a cliff 30 feet high, consisting of dark grey bituminous limestone, inter-stratified towards the bottom with earthy drab limestone, all weathering to a drab color. Half way down the rapid, this cliff is about 20 feet and at the bottom about 40 feet in height. The thickest beds measure about 2 feet, and occur towards the top. A similar cliff runs along the opposite side of the rapid. The dip is southeastward, at the rate of one in fifty to one in one hundred. Fossils are not common in these rocks [Corniferous]." (35)

"In ascending the Kenogami river, we have a repetition of the geological conditions which were observed on the Albany. From The Forks to Mamattawa, drab and chocolate-colored marls and interstratified bands of earthy yellowish limestone are exposed in a few places. Following up the stream, at about 7 miles above Mamattawa, the bottom of the river is composed of beds of limestone, which are in places somewhat disturbed.

"The river between this spot and the Albany appears to run upon the axis of a slight anticlinal. At the end of the seven miles indicated, we enter between banks composed of chocolate-colored marl interstratified with bluish-green bands, and varying from 50 to 80 feet

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(31) Roy. Com., 1890, p. 44.

(32) Ibid, p. 45.

(33) Ibid, p. 47.

(34) G.S.C., 1870-71, p. 330.

(35) Ibid, 1875-76, p. 316.

High grade limestone quarry, Anderdon, in springtime, showing dip of strata. Essex County.

Quarry of gray dolomite, Anderdon, showing floor of high grade limestone. Essex County.

Plant for crushing limestone at Anderdon quarries. Essex County.

Gray dolomite bluff, Anderdon quarries, showing debris from quarrying block stone. Essex County.

Lime kiln at Limehouse. Halton County.

in height. These banks continue on both sides, almost uninterruptedly for about 10 miles up the stream. Above this the banks, which maintain almost the same height, especially on the southern side, are mostly composed of stiff gravelly clay, with boulders, but the chocolate-colored marl is seen here and there almost to Pembina island." (36)

Brant

"The most southern exposure of the summit of the formation [Guelph], on the Grand River, occurs just above Middleton bridge, on the twenty-first or twenty-second lot of the sixth range of Dumfries. The rock is a light grey dolomite, weathering to a pale drab. . . Similar beds, with others of a pale buff color, continue up to the north end of the fourteenth lot of the sixth range of Dumfries, with a very gentle dip to the southwest; the distance across the measures being probably two miles. . . The rocks of the Guelph formation are again met with, farther up the Grand River, in the vicinity of Galt." (37)

"At Paris, on the east bank of the river, between the Great Western Railway viaduct and Mr. Wright's plaster bed, the strata of this part of the formation [Onondaga] are very well exposed. Here we have eight or ten feet of tender, brittle, greenish argillaceous dolomitic rock, often red weathering, and passing into a shale. This is overlaid by three feet of dove-colored dolomite, vesicular below, with thin eroded cellular beds; followed by a bed of one foot, compact above, but cellular below, and succeeded by a foot or more of vesicular beds. These are overlaid by about a foot of conglomerate, apparently of vesicular dolomite, with fragments of green shale; the upper part very ferruginous and decomposing. The whole is overlaid by green shales, more tender and crumbling than those below. These strata are slightly undulating, and as they are concealed near the gypsum quarry, it is not easy to give the exact horizon of this. The upper part of the gypsum bed is intercalated with much dolomite, and for two feet seems made up of alternating lenticular masses of gypsum and dolomite, the latter prevailing at the top, and succeeded by thin bedded cellular dolomite, one portion of which seems to have been broken and recemented. Examples of this are seen on the other side of the river just below the viaduct, where the green shales are overlaid by masses of similar dolomite, often stained red, and having apparently been broken and recemented into a kind of breccia." (38)

"Proceeding westward from Ancaster no exposures of rock are encountered until Woodstock is reached, at which point the erosion of the Thames has removed the glacial debris from the underlying Corniferous limestone. Both north and south of the highway rock is to be seen, not, however for some distance west of Ancaster. The road from this place to Brantford reaches the summit about two miles out and then traverses a level clay country. At Brantford although no rock is normally exposed, it has been encountered above the dam at about 15 feet below water level, and below the dam about five feet down. An opportunity was had of seeing a small piece removed in making excavations for new piers for the Brantford Power and Light Company. The sample was a hard compact gray limestone with a distinctly glaciated surface; the direction of glaciation was of course indeterminable, the rock not being in place. Conversation with workmen led to the opinion that both the striae and dip of the rock had a southwesterly direction.

"At Brantford post-glacial gravel lies directly on the rock; it is almost continuous as far as Galt and also extends west to Burford. Southward, however, it gives place to clay; for at the Cockshutt bridge, two miles south of Brantford, forty feet of continuous clay, devoid even of sandy partings, was pierced in making foundations for a new bridge.

"These post-glacial beds consist mainly of coarse sand with pebbles mostly of limestone, but many of the Archaean rocks are also represented, sometimes by fragments of considerable size. Continuing south from Brantford, clay deposits alternate with gravel, the country gradually growing less hilly to the vicinity of Waterford. South of this place several interesting exposures of Corniferous rock are to be seen. Stratified gravels prevail in the immediate vicinity of Waterford, but on passing south towards Rockford they again give place to clay, which is practically continuous to the shore of lake Erie." (39)

"Returning to Brantford, the north and south section was continued farther north, the first exposures being seen in the banks of the river at Paris, where the Onondaga or gypsum-bearing formation is encountered. Near the bridge over the Grand river at this place fifteen feet of soft, thin-bedded shales with interlaminations two to four inches thick of soft limestones are exposed. An analysis of this limestone was made to ascertain its general nature and its content of gypsum, of which substance it proved practically free, as a glance at the analysis will show:

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(36) G.S.C., 1871-72, p. 113.

(37) Ibid, 1863, pp. 338-9.

(38) G.S.C., 1863, p. 350.

(39) B.M., Vol. 12, p. 142.

	Per Cent.
Water	0.33
Insoluble residue	3.32
Calcium oxide	27.77
Magnesium oxide	15.15
Carbonic acid	33.42
Sulphur	0.60

"In spite of its association with the gypsiferous shales, this rock is therefore very free of both alumina and sulphur. The uppermost layers however are more cavernous than the typical rock analysed, and contain small particles of gypsum. The shaly portions are soft and friable, and resemble the Don Valley shales of the Hudson River formation as exposed near Toronto. These shales are practically the same as the slate at gypsum quarries, of which an analysis will be given later.

"At Paris the rock is covered by a thick deposit of post-glacial gravel similar to and probably continuous with that at Brantford. About a mile and a half below the town are situated the gypsum quarries or 'plaster mines,' as they are called locally. The Grand has followed out its bed through the gravel which rises to an elevation of 100 feet or more above the high water level, at which point the rock is exposed for a half mile along the river. The method of quarrying is to run tunnels about five feet square into the hillside and to enlarge these passages into chambers where good material is encountered. The product, as brought to the mouth of the tunnel, consists of mixed slate and gypsum, both gray and pure white in color. The gypsum occurs in irregular cracks in the shale with its fibres arranged at right angles to the walls, or as selenite in ramifying veinlets traversing the slate in all directions. Some portions of the rock are filled with crystals of gypsum, while in certain places the valuable material seems interbedded. Speaking roughly, the white product would average about 15 per cent. of the rock quarried. The residue, however, contains more or less gypsum and is ground and sold for land plaster. The slate assays as follows:

	Per Cent.
Water	0.75
Silica	52.02
Alumina	8.03
Ferric oxide	3.80
Calcium carbonate	9.90
Magnesium carbonate	2.34
Sulphur	1.00

"At present three men are working in a tunnel which has been driven about 600 feet into the hillside, and which has been worked for nine years. Previous to this tunnel fourteen others, some of them extending to greater distances into the hillside, had been excavated. At various other points along the river valley similar deposits occur, and there is no doubt that a practically inexhaustible supply of the material exists in the vicinity.

"The Paris waterworks are situated two miles above the town, at which point a copious spring bursts out of the gravel. The water is somewhat calcareous, as is seen in considerable deposits of travertine containing impressions of leaves and various small organisms. These are the only fossils to be seen in the vicinity." (40)

Marl

"On lots 18, 19, 20 and 21 of the first concession, South Dumfries, an excellent deposit of marl is seen in Blue lake which itself covers 10 acres, while the marl beds probably extend over 40 acres. The deposit would average thirty feet in depth of pure white marl, said to contain 96.83 per cent. carbonate of lime. The hills surrounding the lake are of moraine origin and show no stratification. Clay occurs in the hillside to the north of the pond. This location is very well disposed for the stablishment of a cement plant, as a spur of 1,000 feet would suffice to put the product on the rails. Some work had been done, at the time of my visit, with the object of establishing a cement works on the property, which has been acquired by the Ontario Portland Cement Company, of Brantford, with Mr. E. L. Gould, Brantford, as president, and Mr. W. G. Elliott, manager." (41)

Bruce

In the following quotations a summary description is given of the important limestone outcrops in the county of Bruce.

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(40) B. M., Vol. 12, pp. 147-8.
(41) Ibid, p. 149.

"The same two formations [Medina and Clinton] occupy the lake front of the townships of Albemarle and Eastnor, with the exception of the peninsula terminating in Cape Crocker. This consists of Hudson River strata; and is overlooked from the westward by a bold escarpment, in the lower part of which the two formations occur. The summit of the Medina series disappears beneath the waters at Cape Dundas, while the Clinton continues along the water line, as far north as Cape Chin, rising at Cape Gun, and Point Hungcliff to about the height of a hundred feet.

"At Cabot's Head, the very summit of the Medina formation is seen at the water's edge, and there rest upon it about twenty-six feet of dolomite similar in its coloring and its weathering to that of Owen Sound, which it also resembles in holding silicified fossil. . . . On the dolomite, repose 103 feet of red marly sandstone, partially striped and spotted with green, and interstratified with beds of red and green argillaceous shale; none of which exceed six or eight inches in thickness. The green argillaceous beds appear to be quite free from calcareous matter, and the stone is carved by the Indians into tobacco pipes. These red and green strata are succeeded by about fifty-five feet of green calcareo-argillaceous shales and thin-bedded limestones and terminated by the massive limestones of the Niagain series." (42)

"Farther on, escarpments of twenty- or thirty feet of the limestone [Corniferous], run through the west half of Carrick, and are said to extend southward into Howick; while, to the north, the outcrop of the formation crosses the south-west corner of Brant [township], and is seen upon the Teeswater, near the east line of Greenock. The general trend of the strata would bring them upon Lake Huron, near the mouth of the Saugeen River. No exposures have, however, been observed at this point, nor for seven miles to the south-west, along the coast. Beyond this, however, nearly horizontal buff-colored beds appear, at about two feet above the edge of the lake; holding numerous organic remains, which are frequently replaced by chert. These beds come out at intervals along the shore, the surface of the same stratum being sometimes exposed for a considerable distance; they occupy altogether a distance of four or five miles. . . . Beyond this another interval of concealment occurs, to within three miles of Point Douglas. Here, a yellowish calcareous sandstone skirts the coast line; and proceeding along the beach towards the point, the sandstone is found to be associated with calcareous beds, holding numerous nodules of chert, with black bituminous shales, and blue and drab dolomites; one bed among which is fit for hydraulic cement. The whole of these strata appear to be devoid of fossils; but they contain crystallized celestine, quartz and calcite, in geodes and fissures. A black band, of a coarsely crystalline granular texture, overlies the sandstone, and appears to be composed of an aggregate of imperfect crystals of calcite; while the color results from the presence of bituminous matter, which exists, in a greater or less proportion, in all of the beds. Ascending in the section, which at Point Douglas displays a thickness of twelve feet, thin calcareous beds of a dark color occur, separated by very thin layers of black bituminous shale. Above them the upper part of the cliff is occupied by thin blue layers with pale yellowish beds, sometimes more than a foot in thickness, marked by small lenticular crystals of brownish calcite, and by epsomites. Portions of these non-fossiliferous strata continue to occupy the coast to the southward, with gentle undulations, to a point about half a mile beyond Little Pine Brook. Here, fossiliferous cherty beds, similar to those on the other side of Point Douglas, are seen, overlying the highest of the strata already mentioned, in detached isolated portions, for upwards of a mile; beyond which, no rock is exposed for upwards of twenty-five miles.

"Near the village of Kincardine, in the sixth and seventh lots of the township of that name, is a quarry, on the land of Mr. C. R. Barker, where from fifteen to twenty feet of the formation are exposed, consisting for the most part of thick bedded light and dark grey granular limestone, which are quarried both for building stone and for burning, and yield a very white lime. The lighter colored beds contain a few corals. No chert was observed here, but the rocks are bituminous; and towards the top are thinner beds, interstratified with layers of a dark brown inflammable shaly limestone, some specimens of which contain a large proportion of asphaltum." (43)

"The Onondaga or gypsiferous formation, which overlies the preceding rocks, consists chiefly of a dolomite, which is generally too thin bedded for building purposes. On the fourth lot of the second range of Brant, however, at the Oxbow on the Saugeen River, it presents several thick beds of a very fine-grained yellowish grey dolomite, which appears to be well fitted for architectural purposes. It is free from stains, may be split with regularity, and works with facility; when fresh from the quarry it may be cut with a saw, but soon hardens on exposure. Two bands of this stone, each about ten feet in thickness, occur in this formation. The higher one, which is at its summit, is here exposed at the surface; and offers facilities for quarrying. It is made up of massive beds, some of them two feet in thickness; and a bed of three feet occurs in the lower band. Beneath the upper band is a bed of light grey oolitic rock seventeen inches in thickness which has been used with advantage in the neighborhood for supporting the axles of mill-wheels." (44)

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(42) G.S.C., 1863, pp. 319-20.

(43) G.S.C., 1863, pp. 371-5.

"Beds of a fine-grained yellowish-grey stone, well fitted for lithographic purposes have lately been found among the dolomites of the Onondaga formation in the township of Brant. They occur in the bed of a small stream, about half a mile south of Walkerton, where several strata of the stone from two to eleven inches in thickness occur in a section of fifteen feet. The beds at this place are traversed by natural joints, which cause the rock to divide into somewhat narrow portions; but the stone is found to be well adapted for lithography, and larger slabs may probably be found elsewhere in the same formation. Equally good specimens of it were obtained from the Oxbow on the Saugeen River, on the third lot of the seventh range of Brant. The stone from this formation, being magnesian, is attacked by acids more gently and with less effervescence than ordinary limestones. This peculiarity in the action of acids, which are employed in the lithographic process, is said to be an advantage." (45)

"Exposures of thin bedded dolomites [of the Onondaga formation] are met with, at several points, nearly to the mouth of the Saugeen. About a mile below the village of Paisley, in the township of Elderslie, strata of this kind are seen, containing small lenticular crystals of calcite. The lithological characters of many beds at the summit of this formation are, however, so much like those of the overlying water-lime group, that it is not easy to draw a line of division between them." (46)

"The base of the limestone [of the Niagara escarpment] comes upon Colpoy's Bay, and crosses it probably about two miles and a quarter from its bight. Thence it keeps rather close upon the north side of the bay; while the escapment gradually rises, according to Bayfield's chart, to a height of 350 feet above the level of Lake Huron in the bluff which faces Hay Island, to 300 feet in the next bluff north; and to 200 feet in Cape Paulet. The Clinton formation occupies perhaps a hundred feet at the base of the most southern bluff, and is seen in the second; but the summit of the formation comes to the level of the water at the extremity of Cape Paulet. The cliffs along the coast, from this to Cape Chin, are altogether occupied by the Niagara escarpment, and vary in height from 130 to 150 feet, being often nearly vertical. The limestone of which they are composed approaches to white in color; the beds are massive, and a majority of them appear to be magnesian. These cliffs would supply an unlimited amount of a superior material for the purposes of construction. The limestone abounds in corals. . . .

"The summit of the cliff at Cabot's Head is, by measurement, 324 feet above the lake, 184 feet of this, at the base, are occupied by the Clinton formation; leaving only 140 feet of the Niagara formation in the escarpment. In the transverse section presented by the coast between Cabot's Head and Cape Hurd, higher portions of the series are, however, met with. The coast intersects the strata obliquely; but from the position where the base of the limestone comes to the lake, the distance to the strata of Cape Hurd would be, at right angles to the strike, about 12 or 13 miles. The slope of the strata, as ascertained by a measurement of two miles and a half, being about 37 feet in a mile, the whole thickness of the limestone, provided the dip is constant, would thus be about 450 feet. It is probable, however, that the slope diminishes towards the main body of the lake; this may considerably reduce the thickness, and some part of the strata may belong to the succeeding formation. The rock is a pale buff or yellowish white, and weathers to a drab. It is divided into massive beds, many of them being 9 and 10 feet thick; they are cut into rhomboidal forms by two sets of parallel joints, one running N. 85 deg. E, and the other S. 29 deg. E. Some of the thickest beds appear to be a mass of corals, and most of them present a very rough and irregular exterior. Great blocks of the rock, some of them fifty tons in weight, have fallen from the cliffs, and are scattered along the shore. . . .

"It seems probable that the coast from Chief's Point to Cape Hurd, a distance of 50 miles, runs very nearly on the strike; but it has still to be ascertained whether the coast may not include some part of the succeeding formation. The rock, all the way, is a whitish sub-crystalline magnesian limestone, presenting at Tobermory Harbor, Lyell Island, the mouth of the Riviere aux Sables, near Chief's Point, and other places, a number of characteristic fossils. The Rankin River, falling into the Riviere aux Sables (north), discharges the waters of a chain of lakes, which, with the river first named, occupy a valley running parallel with Lake Huron, for ten miles; at a distance of two miles from it. A low escarpment occupies the west side of the valley; but we have not yet been able to ascertain whether this may give clearer evidence of the true summit of the Niagara rocks than is afforded by the coast." (47)

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(44) G.S.C., 1863, p. 821.
(45) Ibid, p. 835.
(46) Ibid, p. 351.

Marl

"Deposits of this material are abundant in the counties of Bruce and Grey. One of these, on the twenty-fifth lot of the fifteenth range of Carrick, covers about six acres and was found to have a depth of twenty-seven inches. It is very pure and white, and is covered with a thin layer of black mould, forming the soil of a meadow. Other deposits, estimated at forty acres in all, occur in the immediate neighborhood. On the sixth lot of the first range of Brant, north of the Durham road, marl occurs in a peaty meadow, beneath a foot of soil. It is two feet in thickness and extends over seven acres. Another locality in the same township is on the seventieth lot of the first range, south of the same road; where it is seen in the banks of a little stream, near its junction with the Saugeen, and has in some places a thickness of three feet." (48)

Carleton

The geology of this and adjoining counties has been described during the last decade by Dr. R. W. Ells, Dr. H. M. Ami, the late Mr. N. J. Giroux, and other officers of the Geological Survey. The reader is referred to the reports and maps published by these gentlemen for details concerning the distribution of the limestone-bearing formations—the Calciferous, Chazy, Black River and Trenton. (49).

The limestones, especially the Trenton, of the county have been quarried extensively for lime-burning and for building stone. The largest quarries now operated are Robillard's, on the Montreal road, about three miles from Cumming's Bridge. Many old quarries have been abandoned for some years. Large quarries are situated near Hog's Back on the east side of the Rideau river. These are in the Trenton. That the limestone of this formation is here very pure is shown by the fact that the Portland cement plant now being constructed at Hull is to use this rock as the source of calcium carbonate.

Among the largest quarries in the Chazy is that known as Wright's cement quarry on the south side of the Ottawa above Mechanicsville. The stone from this quarry is referred to under the heading devoted to cement.

"In the eastern areas the Palæozoic formations are well developed, the principal being the Postdam sandstone and the Calciferous limestone, which are particularly well exposed in the south-eastern part of Lanark county and the southern portion of the county of Carleton. The beds of these formations are in a nearly horizontal position, though in places they are inclined at angles of ten to fifteen degrees. They constitute the lowest members of the Ottawa Palæozoic basin and rest directly upon gneiss and limestone of the Archæan. In the townships of Huntley and Nepean, as also in Ramsay, the Calciferous passes regularly up into the Chazy and on into the Black River and Trenton. There is usually a gradual passage upward from the Potsdam sandstone into the Calciferous limestone, and in places these transition beds are from thirty to fifty feet thick. This portion frequently contains an abundance of fossils, as in the township of Goulbourn, though they are not often easily obtained in a good state of preservation." (50)

"Between Britannia and the Chats Falls, which forms the first break in the navigation, the rocks along the south shore are divisible into Calciferous and Chazy. The former of these constitutes a belt nearly six miles in breadth, between Brittania and Berry's Wharf, the rock being chiefly a buff-weathering dolomitic limestone. The limestones cross the river and show along the beach on the north shore for several miles above the town of Aylmer, where they are overlaid by green-gray Chazy sandstones and shales. On the south side, these latter extend from below Berry's Wharf to Fitzroy Harbor at the foot of the Chats Falls, capped on the tops of the hills inland by Chazy limestone, which also appears along the shore in the township of Torbolton, about Buckhams Bay, where the rock has been extensively quarried for building stone. Further inland, the Calciferous rests upon and passes into the Potsdam sandstone. This flanks on the north and east, a long tongue of Laurentian gneiss and limestone, which extends south and east from Fitzroy Harbour to within ten miles of the city of Ottawa. These crystalline rocks have associated with them large areas of intrusive syenite and diorite which have broken through the crystalline limestone and associated gneiss. . . .

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(47) G.S.C., 1863, pp. 331-3.

(48) Ibid, p. 764.

(49) G.S.C., 1899, G., etc.

(50) G.S.C., 1897, p. 58 A.

"The rocks between Fitzroy Harbour and Arnprior, on the southern side of the river, are mostly crystalline limestones of Laurentian age, cut by numerous dykes and masses of reddish syenite and diorite." (51)

"This, and the two following stones, represent the material of three of the more important beds (here referred to in descending order) at Messrs. H. Robillard & Son's quarry on the twenty-second lot of the first concession of Ottawa Front, township of Gloucester. . . Geological position—Trenton formation, Cambro-Silurian.

(1) "Stone from the first bed. Thickness of the same, eighteen to twenty-four inches. Structure, moderately fine-crystalline; color, dark gray. Its composition was found by Mr. Wait to be as follows: (after drying at 100 degrees C. —Hygroscopic water, 0.03 per cent.)

Carbonate of lime.....		97.87
Carbonate of magnesia...		1.13
Phosphate of lime (tribasic)	0.39*	
Alumina...	0.04	
Silica, soluble....	0.05	
Bisulphide of iron....	0.13†	
Insoluble mineral matter ..	0.59	
Organic matter	0.08	1.23
		100.28

* Corresponding to 0.079 phosphorus.
† Corresponding to 0.07 sulphur.

"This stone is extensively quarried for structural purposes.

(2) "Stone from the third bed of Messrs. H. Robillard & Son's quarry. This bed has a thickness of from fifteen to twenty inches. Structure, fine crystalline; color, light gray. An analysis by Mr. Wait afforded the following results: (after drying at 100 degrees C. —Hygroscopic water 0.04 per cent.)

Carbonate of lime.......		98.25
Carbonate of magnesia...		0.72
Phosphate of lime (tribasic)	0.37*	
Alumina	0.04	
Silica, soluble.....	0.02	
Bisulphide of iron........	0.06†	
Insoluble mineral matter...	0.60	
Organic matter	0.04	1.13
		100.10

*Corresponding to 0.074 phosphorus.
† Corresponding to 0.03 sulphur.

"This stone is largely used for building purposes.

(3) "Stone from the fifth bed of Messrs. H. Robillard & Son's quarry. Thickness of bed, twelve to twenty inches. Structure, somewhat coarse-crystalline; color, faintly brownish light gray. An analysis by Mr. Wait, gave as follows: (after drying at 100 degrees C.—Hygroscopic water 0.06 per cent.)

Carbonate of lime		98.68
Carbonate of magnesia...		0.90
Phosphate of lime (tribasic)	0.17*	
Alumina...	0.17	
Silica, soluble...	0.02	
Bisulphide of iron...	0.04†	
Insoluble mineral matter ...	0.32	
Organic matter...	0.01	0.73
		100.31

* Corresponding to 0.035 phosphorus.
† Corresponding to 0.02 sulphur.

"This stone is employed for building purposes." (52)

(4) "From an outcrop on the southwestern side of Hemlock Lake, township of Gloucester. Geological position, Chazy formation, Cambro-Silurian.

"A very fine-grained and compact, greenish-gray, yellowish-brown and reddish-brown weathering, massive limestone. An analysis by Mr. Johnston showed it to have the following composition: (after drying at 100 degrees C.—**Hygroscopic** water 0.98 per cent.)
cent.)

Lime...	19.78
Magnesia...	10.55
Alumina...	0.75
Ferric oxide	0.27
Ferrous oxide...	1.71
Manganous oxide...	0.38
Carbonic anhydride	26.03
Sulphuric anhydride....	0.07
Phosphoric anhydride...	0.14
Silica, soluble...	0.60
Water...	0.20
Insoluble mineral matter	38.81
	99.20

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(51) G.S.C., 1894, pp. 58-59 A.

(52) G.S.C., 1899, pp. 32-33 R.

"The insoluble mineral matter consisting of :

Silica...	24.20
Alumina.....	6.77
Ferric Oxide....	3.23
Magnesia.	1.47
Potassa...	1.46
Soda..	0.13
Water (ignition)...	1.53
	38.81

"The band from which this argillaceous magnesian limestone was taken has been supposed to be an extension of the beds affording a cement-stone, which are worked by Mr. C. B. Wright on the thirty-fourth lot of the first concession, Ottawa Front, of Nepean township, in the above-mentioned county of Carleton. (53)

Marl

"From a deposit on the east side of MacKay's or Hemlock Lake, lots one and two of the Junction Gore of the township of Gloucester, Carleton county. The deposit has a thickness of about five feet, but its extent is not known.

"The air-dried material is earthy, slightly coherent; color, yellowish-white. It contains numerous shells, also root fibres.

"Agreeable with the results of an analysis, conducted by Mr. F. G. Wait, it has the following composition : (after drying at 100 degrees C.—Hygroscopic water 0.46 per cent.)

Lime...	52.24
Magnesia...	0.13
Alumina...	0.13
Ferric oxide....	0.09
Potassa......	traces.
Soda	do.
Carbonic acid...	41.16
Sulphuric acid...	traces.
Phosphoric acid...	0.02
Silica, soluble...	0.11
Insoluble mineral matter	1.08
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	4.[illegible]
	99.86

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 93.29 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of : (54)

Silica.....	0.72
Alumina and ferric oxide......	0.24
Lime.......	0.04
Magnesia...	0.02
Alkalies...	0.06
	1.08"

Dufferin

In this county the Clinton strata "are limited by a bold escarpment, composed of the rocks of the Niagara formation, which succeeds" or overlies them. "The inclination of the measures being very small, probably not exceeding thirty feet in a mile, the outcrop of the series, particularly at the summit, presents a very indented outline, running into deep bays in the valleys of the principal streams where bold ravines are worn in the rock above, (e.g., on the Nottawasaga in Mono). Several minor undulations occur north of this, in Mono and Mulmur."

"Though the Clinton strata are thus easily traced by the conspicuous escarpment which rises precipitously above them, they themselves are but seldom seen, being for the most part concealed by a talus of debris." (55)

"The river Credit, in Caledon, is flanked on both sides by the cliffs of the Niagara limestone, in some places a hundred feet high; these, in ascending the valley, meet on the ninth lot of the fourth range of the township, near Bellefontaine, and form a crescent-shaped precipice, over which the river falls in a cascade. In the valley of the Nottawa, similar cliffs prevail; and at Orangeville some of the rock, of a yellowish-white, would take a sufficient polish to constitute a very useful marble. The cliffs continue through Mulmur and Nottawasaga." (56)

Quarries are worked in the limestone near Orangeville, and in other parts of the county.

Dundas

The following notes describe the general distribution of the limestone formations in this county. Additional information will be found in recent Summary Reports of the Geological Survey [illegible]

the nort[illegible]
burg. al[illegible]
right [illegible]
Nation[illegible]

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(53) G.S.C., 1898, Vol. II., p. 19 R.

(54) [illegible]

(55) Ibid

(56) Ib[illegible]

erly exposure of black limestone met with, connected with the southern division of the Ottawa and St. Lawrence trough, it is probable that it may belong to the Birdseye and Black River formation. There is nothing to contradict this view in the aspect of the rock, but no fossils have been obtained to confirm it. Farther down the river, at the eleventh lot of the second range of Winchester, similar beds hold Leperditia; but here also the formation is uncertain. Still farther down, at Armstrong's Mills, on the twelfth lot of the fourth range, and in several places in the neighborhood, quarries are opened in black limestone beds, but there they are characterized by Trenton fossils. From this vicinity similar limestones occur at intervals all the way to Crysler's mills, in Finch, and nearly the whole of the township appears to be underlaid by such strata in a generally horizontal attitude." (57)

"The town of Iroquois is apparently nearly on the eastern limit of the Calciferous, on this shore of the river, since at Sheik Island the next recognized outcrop is of the dolomitic limestones at the base of the Chazy formation." (58)

"Few mineral substances are found in the area to the south of the Ottawa in economic quantity. Quarries are, however, numerous and are situated generally in the limestones of the Black River formation, which has been found to yield the best quality of stone for building purposes. Others have, however, been worked in the limestones of the Calciferous, Chazy and Trenton, as also in the heavier sandy beds at the base of the Chazy, which are especially well suited for foundation work. There is a large quarry of this rock about two miles east of the village of South Mountain, on lot 2, range I., Mountain township. The most important quarries in the Chazy limestones are near the village of Winchester, on the road thence to North Williamsburg. The rock here is used both for lime-burning and for building stone. On lot 7, range I., Winchester, there is an excellent quarry of flaggy limestone in layers of about six inches thick, from which flags of any required size can be obtained. This is owned by Mr. William Bolton. A similar flaggy limestone is seen in a quarry on lot 39, range VIII., Williamsburg. These are near the base of the Chazy limestones, while most of the Winchester quarries are in the grayish somewhat nodular limestones belonging to the upper portion of that formation." (59)

"About two miles, in a northeasterly direction from Van Camp's Mill, Calciferous limestone occurs in thin beds and much disturbed, with characteristic vugs of pink and white calcite. This place has been opened as a quarry.

"The formation is also well exposed in the neighborhood of South Mountain, and all along westward of this place. . . .

"On the road from Mountain to Smirleville, similar outcrops (Calciferous) also appear, and at about one mile and a half north of Mountain station, this limestone is full of rounded and angular pieces of quartz, varying in size from a pea to a melon, and angular pieces from a fourth of an inch to a foot across. This conglomeritic rock has a very homogeneous matrix, which exhibits plainly all the characters of the Calciferous. The dip of these beds on the south of the exposure, is S. 20 degrees E. < 18 degrees, and on the north side is about 100 yards wide, the dip is N. 10 degrees W. < 12 degrees.

"The Calciferous also appears near Ormond Corner in the township of Winchester, Dundas county, in beds of limestone, as well as on the east point of Racket River, on the south side of the St. Lawrence, where ledges of dark-gray, sandy limestone outcrop. The south shore of the river northward for some distance from this place, is low and without rock exposure, but Calciferous blocks are numerous." (60)

"Limestones of this age (Chazy) are also seen about two and a half miles west of Grantley, and at about three miles south of Chesterville. They also appear, associated with shales, about two miles northeast of West Winchester, as well as on lot 22, range XII., Winchester township." (61)

Durham

"In Darlington and Clarke, according to Dr. Bigsby, the Silurian boulders (limestone) generally occur in groups, and not scattered like those of Laurentian origin." (62)

"At the latter place [Cobourg], and between it and Port Hope, there are some small exposures of blackish-gray, thin-bedded nodular limestone and shale, which, among other Trenton fossils hold Lingula Canadensis and Asaphus megistos.

"The farthest up exposures of Trenton limestone, near the lake shore, occur about a mile south of the village of Oshawa in Whitby, where the dip is N. < 25 degrees; and at Bowmanville, where a quarry has been opened for the purposes of the Grand Trunk Railway, at the summit of the formation. The strata here dip to the northwestward at a small angle, and, as the must finally crop out with a southward dip, it is plain that the beds of the quarry are on a southward side of a synclinal form, and that, after running to the northeast on the strike for some uncertain distance under the drift, they must ultimately turn northward to conform to the deeper strata seen farther northward." (63)

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(57) G.S.C., 1863, p. [illegible]73.

(58) G.S.C., Sum. Rep., 1899, p. 134.

(59) Ibid. p. 136.

(60) G.S.C., 1896, p. 62 A.

(61) Ibid, p. 62 A.

(62) Ibid, 1863, p. 895.

"The most eastern exposures of the Utica [shale] formation, on the north shore, are just above those of the Trenton already mentioned as occurring to the south of Oshawa, and near to Bowmanville." (64)

Elgin

This county is drift-covered and few descriptions have been published of its geology. It is believed to be underlaid chiefly by the Hamilton formation, although the Corniferous appears to lie directly under the clay in some localities. In a well drilled at Vienna 35 or 40 years ago it is said that Corniferous limestone was met with beneath 240 feet of clay. The point at which the drilling was done lies about 40 feet above Lake Erie. (65)

The following log gives information on the underground geology of another part of the county:

"At about the same time that the boring at Vienna was made, one was also made at Port Stanley, to a depth of 298 feet. The record is as follows: [probably all Hamilton] (66)

	Feet.
Surface..... :...	172
Black and brown shale........	30
Light coloured shale.........	16
Limestone.....	80"

Essex

Rev. Thomas Nattress, B.A., has kindly furnished the writer with the following interesting account of the limestones of Essex county, together with photographs of the quarries which are reproduced in this report.

Anderdon Quarries

"The exposures are in Anderdon township in the southwestern part of the county, and on Pelee island, in lake Erie.

"In Anderdon, within a few hundred yards from south to north, there is an outcrop of three several qualities of limestone (67). The overlying deposit is a magnesian rock, gray in color, of which some 32 feet in depth has been exposed in quarrying. There are some indications that the thin bedding that forms the surface deposit on Pelee island begins not far south of this point of measurement, going to show that the approximate maximum depth has been reached. There are five beds of this dolomite, measuring, from above downward, two, eight, four, eight and ten feet in thickness respectively. The lower eight-foot bed is unsurpassed as dimension stone. The four and ten-foot beds are also of very fine quality, the latter, however, showing some chert. An analysis of the former, the four-foot stratum, shows $CaCO_3$ 60.903, $MgCC_3$ 36.463, $CaSO_4$ 0.071, $(FeAl)_2O_3$ 0.230, SiO_2 2.350.

"The surface beds, so far as exposed, are somewhat weathered, and are used for foundation stone, and road material. The quality will doubtless improve as quarrying advances in the direction of the dip. The top layer is crinoidal by contrast, and may be found to yield a fair quality of lime.

"The block stone for the locks on the first canal on the American side, at Sault Ste. Marie, was taken from these dolomite beds. So also the stone for the locks in our own canals at the same place.

"Immediately under the gray dolomite is as pure a limestone as could be desired. A large surface area is exposed and quarrying has been carried on to a depth of 25 to 30 feet. Analyses made by the Solway process people at Detroit, who own and operate these quarries, show an average of $CaCO_3$ 97.50, $MgCO_3$ 1.50, $CaSO_4$ 0.03, SiO_2 0.80, $(FeAl)_2O_3$ 0.09. Hitherto it has been put upon the market only as crushed stone and foundation stone. A test kiln has lately been put in, of 135 barrels capacity, and excellent lime is burned. One or two beds are of remarkably smooth texture, but the rock is too brittle for lithographic use. Other beds show brecciation to some extent. There is, however, no perceptible deterioration in quality.

"Under the high grade limestone is another dolomite, a fine-crystalline massive rock, a brown stone very desirable for building purposes. A new quarry was opened up in this about two years ago on the property immediately east of the other quarries named. There is but a light stripping of earth and limestone to contend with, yet the stone has not been put on the market. It is a stone that is easily worked: no better could be found for carving. An analysis shows $CaCO_3$ 57.28, $MgCO_3$ 41.15, a trace of $CaSO_4$, $(FeAl)_2O_3$ 0.32, SiO_2 1.25. Some of the lower strata ,as revealed by dredges working in the bed of Detroit river, are very full of a branching coral. The upper beds are entirely free from foreign matter.

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(63) Ibid, pp. 189-90.

(64) Ibid, p. 210.

(65) G. S. C., 1866, p. 290.

(66) Ibid, 1890, p. 49 Q.

(67) See Bureau of Mines Report, 11th Vol., "The Corniferous Exposure in Anderdon," pp. 123-127, in which the geology, crystallography and palaeontology of the district are reported upon.

"The facilities for shipping from these quarries are good. The Michigan Central railway crosses the Solway Process company's property, running almost parallel with and close to the line along which the high-grade limestone runs out. A spur runs down into the gray dolomite quarry to the east side of the property, where the lime kiln is located. On the one side of it is the clean surface of the limestone, on the other the dolomite and the stone-crusher. A mile distant, either by the roadway owned by the company, or by the M.C.R., is the river. There is a dock at the river which belongs to the quarry property.

"The Solway people could use four hundred tons of their own rock from these quarries daily in the manufacture of soda ash at their works across the river. A prohibitive tariff has necessitated their buying another quarry of rock of the same quality in Michigan. As it is they employ eighty men here.

"Two records of well borings may be cited in relation to the Anderdon quarries. The Caldwell Grove well is about two miles south. Here, under eight feet of clay is: limestone, 252 feet; sandstone, 60 feet; limestone, 180 feet; shale and gypsum, 16 feet; limestone (hard), 320 feet and (soft) 297 feet, and another 265 feet, gray shale, 20 feet.

"The Parks well, some three miles southwest, showed 30 feet of sand and gravel; limestone, 228 feet; sandstone, 84 feet; limestone, 182 feet; gypsum, 12 feet ; limestone, 468 feet."

A sample of brown dolomite from the White quarry, Amherstburg, was found by Mr. Burrows to be of the following composition :

	Per cent.
Insoluble matter	1.52
Ferric oxide and alumina	.33
Lime..	30.34
Magnesia..	20.89
Carbon dioxide	46.78
Sulphur trioxide	.18
Total	100.04

Pelee Island

"Pelee Island contains some 13,000 acres of land, and has exposures of rock on the north, west, south and east sides. At the present time active quarrying is carried on at the north end only, in Capt. John McCormack's quarry. Here there is a stone-dock with ample accommodations and depth of water in the immediate vicinity, a part of the quarry property. The first 12 or 14 feet of rock is thin-bedded—as is the case on all parts of the island wherever glaciers have not planed the rock to unusual depth. The first few feet of this is much weathered. Exception should be made, however, in the statement as to both thin-bedding and excessive weathering in the case of two beds within the depths of weathered rock, averaging 10 to 14 inches each. These two strata are remarkably easy of access in each quarry and exposure, except on the east side, where the exposed depth is not sufficient to show them.

"Stone has been taken from the north end quarry during the past year for the filling of the cribs protecting the new Pelee passage lighthouse. There is probably no point in Canada where stone for such a purpose (and stone of the same thin-bedding, but better in quality than is needed for such filling), is quite so accessible as at this quarry. Were a dock to be built at the south side of the island, east of the point that runs out toward Middle Island, the most southerly part of Canada, Pelee itself would furnish an exception, for here thousands of cords are piled up along the rock beach, and are still being brought up from the lake bottom.

"The quarry on the west side of the island is the property of Captain Eugene McCormick, master of the Pere Marquette railroad transfer steamer at Sarnia. It is pre-eminently a block stone quarry, for, though the usual thin-bedding is present, and at its maximum depth, where the greatest amount of quarrying has been done, immediately behind this point almost the entire depth of the overlying formation has been denuded by glacial action.

"Block stone was taken out here for the Welland canal locks. Subsequently a Toronto firm quarried the same stone to be sawn into flags for street paving. The facilities for shipping are good. The new west dock is as fine an island dock as may be found in the country, and is close at hand. A short tramway was used to transfer the blocks from the quarry to boats.

"Considerable testing for oil and gas has been done since 1895. The well known as the Comber well near the centre of the island was the first to be put down of which official record was kept. Drillings examined by Dr. H. M. Ami in 1896 show: Post-tertiary drift, 58 feet; Corniferous, impure fossiliferous limestone, with corals, shells, carbonaceous matter, etc., 222 feet; Oriskany sandstone (more likely the pure glass sand known to the Michigan and Ohio geologists as Sylvania sandstone), 40 feet; Lower Helderberg and Onondaga, gypsiferous dolomite, 458 feet. A number of wells have since been put down in this same neighborhood. Oil has been found, but the flow is indifferent. The same statement holds good of gas.

"Two companies, one a New York company and the other the South Bay Oil Company of Cincinnati, Ohio, are boring at the south end of the island. The latter company have abandoned their first well at a depth of 750 feet, pronouncing it a 'dry hole.' No other test had been completed at the time of reporting. So far as known no well has yet been put down beyond 800 feet.

"Splendid evidence of glacial action is observable everywhere on the high-lying parts of Pelee. The amount and character of the denudation, and the distinctness of the striae, are little short of marvellous. So far as palaeontological evidence goes the formation is the same as on the main shore some 35 miles northwestward in the Anderdon quarries. The variety and relative size of fossil specimens, in the thin-bedded rock, as well as the superincumbent position of the strata, indicate a later development. The high grade limestone extending across Monroe county, Michigan, from the northwest corner of Ohio, in a northeasterly direction, and across the southeast corner of Wayne county, outcropping in Anderdon, is not exposed on the island." (68).

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(68) Geological Survey of Michigan, Vol. VII., Pt. 1.

Samples 1, 2, 3 and 4 are from a quarry on the west side of Pelee island, and represent the character of the stone from near the surface, and from a depth of 6, 8 and 10 feet respectively; 5, west end quarry. Samples 6, 7, 8 and 9 are from the north end of the island. 6, the thicker layer. 8, 12 feet down in quarry. 9, towards bottom of thin bedding. 10, 11, 12 and 13 are from the south end of the island. 14 is from the west side.

Frontenac

This county possesses very valuable resources in its limestones for building purposes. The cheapness with which the Cambro-Silurian limestones are quarries in the vicinity of the city of Kingston and their good quality have caused them to be largely used in the public and other buildings. From this large use of limestone in the buildings has originated the term "limestone city."

The crystalline limestone or marble of the northern part of the county is considered to be of good quality and occurs in great abundance.

Large marl deposits are found in some of the lakes of the county.

Cambro-Silurian Limestones

"On the islands lying in the St. Lawrence, between Kingston and Gananoque, notably on Wolfe and Howe Islands, which are the largest, several good contacts are seen. On the northeast end of the latter, which is several miles above Gananoque, ledges of sandstone occur, in places resting upon the granite and filled occasionally with pebbles of white quartz. These are overlain by the green, grey and black shales, which are found at the base of the cherty limestones, near a small cove known as Bush Bay, about two miles from the lower end of the island. The beds are all horizontal. Some of the shaly layers

ANALYSES OF PELEE ISLAND LIMESTONES

—	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Insoluble residue	......	1.24	......	1.50	1.38	2.20	.90	1.44	2.26	2.51	1.32	1.62	.89	.34
Silica	1.38	......	1.40	......	......	......	......	......	......	......	......	......	......	......
Ferric oxide	.49	.22	.45	.21	.22	.52	.20	.42	.31	.32	.34	.40	.19	.39
Alumina	.45	trace	.47	.20	.43	trace	trace		.12					
Lime	51.60	47.20	43.06	45.14	50.08	43.34	49.70	45.72	43.70	44.36	50.32	45.52	50.04	47.18
Magnesia	2.04	6.06	10.05	7.63	4.40	9.08	4.30	7.22	9.48	8.05	3.49	7.51	4.00	6.10
Sulphur trioxide	.30	.39	.32	.30	.26	.42	.20	.67	.53	.19	.26	......	......	.17
Carbon dioxide	42.80	43.69	42.28	43.51	43.80	43.94	43.65	43.76	44.54	43.59	43.21	43.95	43.59	43.66
Loss	......	1.05	......	1.40	......	.82	.48	.72	......	......	......	1.03	.37	.74
Alkalies	......	......	.40	.40	......	......	.10	......	......	......	......	......	......	......
Total	99.63	99.95	99.17	......	100.68	100.52	99.66	99.95	99.94	99.65	98.94	100.63	99.08	99.58

are very like certain green Chazy shales of the Ottawa basin, but are not quite so hard or slaty. They pass directly up into the limestone which contains Black River fossils, and which thence occupy the whole of the island along the south side. On a road across the island from Bush Bay, the Black River limestone rests upon white quartzite about midway to the north shore. The quartzite is penetrated by red granite, and the latter is seen along the north side of the island below the mouth of Big Bay. The southwest part of the island is all Black River limestone.

"On Wolfe Island the Black River limestone is the prevailing formation. It is seen in low ledges along the shore where this is not occupied by clay or sand.

"The northern part of the island is occupied by the cherty variety with shaley layers, but near the village of Marysville the upper portion of the formation is well seen and contains great numbers of fossils, in which Tetradium fibratum is abundant. These rocks extend south of this to a point opposite the north end of Simcoe Island, when they are overlaid by limestone of Trenton age. The rocks of the Trenton formation apparently occupy all the western end of the island, and are well seen at Bear Point at the southeast extremity, from which a large collection of fossils has been obtained. The rocks of the island are all so nearly horizontal that dips cannot be measured.

"Simcoe and Horseshoe Islands off the west end of Wolfe Island are both occupied by fossiliferous sediments, partly of Trenton age. Garden Island which lies off the city of Kingston, is composed of Black River limestone. Further west, Amherst Island and the whole of the peninsula of Prince Edward county are apparently entirely occupied by the Trenton formation." (69)

"That part of the Birdseye and Black River formation which is well marked by its fossils, after crossing the upper part of Wolfe Island, reaches Cataraqui Point, a little above Kingston, and strikes for the west end of Loughborough lake. From this westward it constitutes a third escarpment, which rises at a varying, but usually not very great distance, back from the two escarpments in which the less fossiliferous strata occur, presenting a bolder and usually more rocky front than either of them. The attitude of the whole series, including the Trenton, which does not usually show any marked escarpment, is for the most part nearly horizontal, the inclination in many instances being so small as to be almost inappreciable. In consequence, it happens that, except in the escarpments and in sections worn out in the courses of streams, the rock is seldom seen, being concealed by a great deposit of drift." (70)

"The more conspicuous and more fossiliferous escarpment presents itself about two and a half miles west of south from the upper one of the other two, on the third and fourth lots of the third range of Lougborough, where beds of brownish-grey bituminous limestone, approaching to brownish black, crop out. . . These beds strike over to the first and second lots of the eighth range of Portland; and beds resembling them are met with on the road between Portland and Lougborough, in the ninth range, about a quarter of a mile from the second escarpment. . . In the eleventh lot of the eighteenth range of Portland, on Pond Lily Lake, the third or uppermost escarpment is from a quarter to half a mile south from the middle one." (71)

"A similar bed [of magnesian limestone] 3 feet in thickness, occurs in the ditch around the fort at Kingston, and has been used as a cement." (72)

Analyses

(1) "From the Bath Road quarry, Bath road, Kingston. Geological position—Birdseye and Black River formation, Cambro-Silurian.

"Structure, compact—containing, in parts, some small inclusions of crystalline calcite; color, somewhat dark bluish-grey.

"Mr. R. A. A. Johnston has made an analysis of this stone, and with the following results:

(After drying at 100 degrees C.—Hygroscopic water, - 0.16 per cent.)

Carbonate of lime		90.07
Carbonate of magnesia		2.52
Carbonate of iron		0.26
Alumina	0.14	7.72
Silica, soluble	0.12	
Insoluble matter	7.46	
Organic matter		0.27
		100.84

"This stone is largely used in the city of Kingston for building purposes.

(2) "From the Wolfe Island quarry, Wolfe Island, opposite Kingston Harbour. From the three-foot bed. Geological position—Birdseye and Black River formation, Cambro-Silurian.

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(69) G.S.C., Sum. Report, 1901, pp. 176-7.

(70) G.S.C., 1863, pp. 183-4.

(71) Ibid, p. 185.

(72) Ibid, p. 806.

"Structure, compact—traversed by an occasional very thin seam of crystalline calcite; color, dark brownish-grey.

"An analysis—conducted by Mr. R. A. A. Johnston—gave as follows:

(After drying at 100 degrees C.—Hygroscopic water, – 0. 12 per cent.)

Carbonate of lime....		94.81
Carbonate of magnesia..........		2.33
Carbonate of iron..........		0.29
Alumina....		
Insoluble matter.......	2.90	3.02
Silica, soluble..	0.12	
Organic matter....		0.28
		100.73

"This stone has been used in several public works, viz., Fern's Point lock, piers and abutments of Kingston Mills, Grand Trunk Railway bridges, and for heavy base courses in several public buildings—and these, after a lapse of some forty years, are said to be in as good a state of preservation as when first built." (73)

Crystalline Limestones

Limestones of this class are widely distributed in the central and northern parts of the county. The distribution of the various bands and belts will be found described in the reports by the late Mr. H. G. Vennor of the Geological Survey. The marbles of the township of Barrie have attracted particular attention.

"North of the Long Lake, an expansion of the Mississippi, the limestone is mostly blue in color and often slaty. This character is well seen along the road from Ardock to the head of Long Lake; but in the vicinity of the intrusive masses the bluish color disappears and the rock changes to a highly crystalline cream coloured mass, in places affording white marble, often of great beauty." (74)

Analyses

"From lot twenty-seven, range nine, of the township of Barrie. Geological position, Laurentian.

"Structure, very finely crystalline; color, pure white.

"An analysis by Mr. R. A. A. Johnston gave the following results: (After drying at 100 degrees C.—Hygrosopic water, – 0.07 per cent.) (75)

Carbonate of lime...	54.02
" of magnesia...	42.63
" iron...	0.64
Alumina...	2.52
Insoluble matter...	
Silica, soluble...	
	99.81"

1. "Is a white and coarsely-crystalline dolomite, from the fourth lot of the tenth range of Loughborough. It leaves when dissolved in acids a residue of quartz and serpentine, and contains traces of oxide of iron and of phosphates. . . .

2. "Is a fine-grained white marble from Mazinaw Lake, and is a pure dolomite. . . . .

	1.	2.
Carbonate of lime......	55.79	53.90
" of magnesia..	37.11	45.90
Peroxyd of iron	traces.	.....
Insoluble quartz., etc. ..	7.10	.....
	100.00	99.80

(3) "A magnesian limestone from the sixth lot of the tenth range of Loughborough is coarsely crystalline, but strongly coherent, snow-white in color, vitreous, and almost translucent. This rock contains small crystals of tremolite, grains of quartz, often rose-colored, bluish and greenish apatite, and scales of yellowish-brown mica. Its analysis gave 4.00 per cent. of insoluble matter and 7.50 per cent. of carbonate of magnesia, with but a trace of oxide of iron. Cold dilute acetic acid dissolved the carbonate of lime, with 3.65 per cent. of carbonate of magnesia; and the residue, which consisted of a mixture of dolomite with the foreign minerals, gave to hydrochloric acid, 36.70 per cent. of magnesian carbonate." (76)

Analyses of crystalline limestones from various parts of Frontenac county are given in the following table:

Constituent.	1	2	3	4	5
Insoluble residue	2.92	....	..		....
Silica	...	3.24	1.50	5.40	1.18
Ferric oxide	.56	1.14	.41	.72	.41
Alumina	trace	.82	.53	.68	.62
Lime	50.12	44.52	49.68	25.02	48.54
Magnesia	3.66	8.00	4.27	23.19	5.27
Sulphur trioxide	...	.29	.06	....	.14
Carbon dioxide..	42.92	40.62	43.38	45.44	43.44
Loss	.08	....	....		
Alkalies......	....		..	.....	.40
Total	100.26	98.63	99.83	100.75	100.00

Sampe 1 represents the white crystalline limestone near Bedford station; 2 is from the kiln near Parham station;

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(73) G.S.C., Vol. 4, 1888-89, pp. 25-6 R.

(74) Ibid, 1896, p. 56 A.

(75) Ibid, 1888-89, p. 27 R.

(76) G.S.C., 1863, pp. 592-3.

3 represents the rock at Reynolds', south of Verona; 4 is from Goodbery's quarry near kiln, Verona; 5 is from a point two miles north of where Goodbery gets stone for his kiln.

Marl

"A great portion of the bottom of Loughborough Lake is a thick deposit of marl; and the bottoms of all the lakes from this to White Lake, in Olden, are in greater or less degree composed of the same material." (77)

Glengarry

Calciferous, Chazy, Black River and Trenton limestones are found in this county. Their distribution is given in the Geology of Canada, 1863, pp. 116, 126, 171-172.

"The Chazy limestone at Hawkesbury and Lochiel also encloses phosphatic nodules, from one-fourth of an inch to an inch in diameter, blackish-brown without, but yellowish-brown within, and giving off abundance of ammonia when heated." (78)

"The railway at Glen Robertson is presumably near the line between the Trenton and Black River, the beds of the former showing to the south and also to the west at Alexandria." (79) The characteristic fossils of the Black River are abundant at the Glen Robertson quarries.

Calciferous Formation

"A valuable quarry in rocks of this formation [Trenton] is located near Alexandria, on lot 27, range V., of Lochiel, about 200 yards to the south of the road. The rocks are heavily bedded and dip S. 10 degrees E. < 7 degrees. They are vertically jointed and blocks of any dimension can be obtained, as the limestone is easily split horizontally. It is highly fossiliferous, and contains small seams of a black bituminous substance. It is rather hard to work, but of very good quality. In places the rock contains small veins of white calcite, and in certain portions has a mottled, pinkish aspect from the presence of pink calcite. In others it assumes a greenish hue, due to a thin coating of a shaly bituminous mineral. This stone is used in the construction of the new Reformatory at Alexandria" (80).

The log of a well drileld for water "on the northern bank of the Garry river, a branch of River Delisle, where ledges of grayish fossiliferous Trenton limestone occur, holding crystals of clear white calcite and small partings of black, shiny, very friable shale," gives the thickness of the limestone strata, as follows:

Depth	Character of rock.	Formation represented and thickness.
Feet.		
0 470	Dark grey impure limestone, holding fossils..............	Trenton ; 470 feet or more.
570	Dark grey impure limestone, softer than preceding ; no fossils detected	Black River ; 100 feet (assumed thickness)
755	Dark gray impure limestone, underlain by greenish-grey calcareo-arenaceous shales—at times fine-grained, at others coarse and more highly arenaceous. Obscure fossil remains detected in the upper calcareous beds...	Chazy ; 185 feet.
786	Hard, compact, dark, chocolate-colored limestone, probably magnesian ; no fossil remains observed	Calciferous ; 31 feet, or more.

"The undertaking was abandoned at 790 feet." (81)

"The Calciferous limestones have a very considerable development on this sheet, and the soil overlying them is generally poor and thin or sandy, unless covered with heavy beds of clay, as in Soulanges county, the eastern part of Glengarry and some parts of Huntingdon.

"The principal places at which the Calciferous formation has been observed are as follows: At Manotick, on the Rideau River, the beds resembling those seen at Glen Nevis. They are also well exposed at Manotick station and to the south of this place. Similar rocks also occur on lot 20, range 6, Osgoode township, Carleton county, the dip of which is S. 88 degrees E. < 6 degrees. They are also well exposed along the road between ranges 6 and 7. Osgoode, from Vernon Corner north for about three miles as also on lot 23, range 12, Mountain, Dundas county, and near Van Camp's mill, and they again appear about three and a half miles west of Winchester, with a dip of S. 45 degrees E. < 4 degrees to 6 degrees.

"About two miles, in a northeasterly direction from Van Camp's mill, Calciferous limestone occurs in thin beds and much disturbed, with characteristic vugs of pink and white calcite. This place has been opened as a quarry.

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(77) G.S.C., 1863, p. 764.

(78) Ibid, p. 462.

(79) Ibid, Sum. Report, 1899, p. 135.

(80) G.S.C., 1896, pp. 62, 63 A.

(81) Ibid, 1895, p. 69 A.

"This formation is also well exposed in the neighborhood of South Mountain, and all along westward of this place towards Kemptville and Merrickville, and southward towards Easton's Corners and Irish Creek. It thence continues on to North Augusta and to the shore of the St. Lawrence as far as Prescott and down the river to Cardinal.

"This formation is also seen on the Castor River, at about three and a half miles southeast of Russell. Sandy calcareous basal beds of the same formation can be seen about two miles south of Smirleville, where they have been greatly altered, and hold pebbles and lenticular pieces of quartz.

"Rocks of this formation extend westward from the eastern half of the township of Grenville, and beds of the same can be seen near Hickston Corners, Hell Gate swamp and Spencerville station on the Prescott and Ottawa railway. On the Nation River, near Spencerville station, the rocks have been disturbed and altered, so that, along with the ledges of characteristic brownish-weathering, dolomitic, fine-grained, gray limestone of Calciferous age, patches of banded sandy limestone occur, which probably are of Chazy age, or else represent much altered portions of the Calciferous.

"On the road from Mountain to Smirleville similar outcrops (Calciferous) also appear, and at about one mile and a half north of Mountain station this limestone is full of rounded and angular pieces of quartz, varying in size from a pea to a melon, and angular pieces from a fourth of an inch to a foot across. This conglomeritic rock has a very homogeneous matrix, which exhibits plainly all the characters of the Calciferous. The dip of these beds on the south of the exposure is S. 20 degrees E. ∠ 18 degrees, and on the north side is about 100 yards wide, the dip is N. 10 degrees W. ∠ 12 degrees.

"The Calciferous also appears near Ormond Corner in the township of Winchester, Dundas county, in beds of limestone, as well as on the east point of Racket River, on the south side of the St. Lawrence, where ledges of dark-gray, sandy limestone outcrop. The south shore of the river, northward for some distance from this place, is low and without rock exposures, but Calciferous blocks are numerous.

"At the bottom of Hungry Bay these limestones appear in a small knoll, holding large pockety vugs of pink and white calcite associated with iron pyrites. Some of the upper beds are slaty, and where the calcite occurs the rock is of a grayish-buff colour, compact and with a very fine grain, almost fine enough to be used for a lithographic stone, were it not that it contains certain inclusions which unfit it for that purpose. The dip is here S. 30 degrees ∠ 5. This place has been opened for a quarry and some of the material used in the construction of the Canada Atlantic Railway bridge was obtained from it.

"The Calciferous also appears on a small brook which empties into the River a la Graisse, lot 17, range VII, Lochiel, but the dip could not here be ascertained.

Chazy Formation

"The Chazy, in this area, has not so wide a distribution, but is generally well defined, both by the character of its shales and sandstones and by the fossils contained in the upper or limestone portion. In the western part of the sheet about one mile north of Manotick station, ledges of bluish-gray and grayish limestones appear, which probably belong to this formation. Not far from Berwick, also, are ledges of dark bluish-gray limestone dip S. 40 degrees E. ∠ 4 degrees. These beds extend northwest from this place as far as Cannamore post-office, and continue on in this direction. A similar rock also occurs in the northern part of Dundas and the southern part of Russell.

"Limestones of this age are also seen about two and a half miles west of Grantley and at about three miles south of Chesterville. They also appear, associated with shales, about two miles northeast of West Winchester, as well as on lot 22, range XII, Winchester township.

"On the north shore of the St. Lawrence, at a small point opposite the northeast corner of Barnhart Island, there is a fine exposure of greenish and black Chazy shales. They are very concretionary and nodular in places but no fossils were observed. The dip is N. 10 degrees W. ∠ 2 degrees. These shales are exceedingly thin and splintery and are easily crushed in the hand.

"At the northeast end of Sheick's Island, opposite Mille Roches, are fossiliferous flat-lying Chazy limestones. A quarry has been opened here and a quantity of material taken out for the construction of the canal. Specimens were collected from these quarries. The limestone at this place is bluish-black in colour, very hard, with a flinty fracture, highly fossiliferous, and holds small dots or specks of clear calcite. It is of fairly good quality, though somewhat seamy in places. On weathered surfaces, which are of a brownish gray colour, it is seen to be concretionary, and the partings of the beds, which vary from six to twenty-four inches, are very rough, blackish and pitted. I am told that 15,000 cubic yards a year have been taken out. The rock, in some places, is in beds of nine to ten feet thick, with generally a parting at about five feet from the surface.

Trenton Formation

"The Trenton formation, with which is associated the Black River, has a very extensive development in this area. In the western part of the sheet, beds are well exposed from Billings Bridge along the main road to Britannia, where also the Chazy is well seen. The Trenton is also well exposed near Mr. Henry Onderdonk's, a short distance to the northwest of Aultsville, as well as in the township of Russell, on one of the branches of the Nation River. It also appears about Crysler in the township of Finch, Stormont county, and thence extends eastward towards Moose Creek.

"Near South Finch, the bed of the Payne River consists of Trenton limestone, and there are also fine exposures about South Finch, Lodi, and other points in the vicinity" (82).

Grenville

The Calciferous is the only one of the limestone-bearing formations reported as occurring in this county. A little above Maitland in the township of Augusta layers of limestone are interbanded with sandstone. Similar exposures are seen down the river to a point a little below the town of Prescott.

"The quarries in the Calciferous formation yield stone principally for local use. The stone is largely dolomitic, but the quarries are not extensive. Along the St. Lawrence east of Prescott, where this formation is extensive, several large quarries are, however, found, and are worked somewhat extensively. The principal quarries in the Black River limestone at Mille Roches, Glen Robertson, etc., have already been referred to" (83). See also under Dundas, Glengarry and other eastern counties.

Grey

"In Collingwood the deposit [the Utica formation in the 3rd and 4th ranges of the township], consists of dark brownish-black shales, interstratified with occasional beds of compact brownish limestone." (84)

Clinton Formation.—"From Collingwood, the general outcrop [of the escarpment] turns to the northwest; but it presents a very deep sinus, southward, up the valley of the Beaver River, reaching nearly to the centre of the township of Artemisia; and another up the valley of the Bighead, in St. Vincent, Sydenham and Holland. A third indentation carries the outcrop a few miles up the Sydenham River, which flows through the town of Owen Sound into the bight of the bay.

"Though the Clinton strata are thus easily traced by the conspicuous escarpment which rises precipitously above them [capped by Niagara strata], they themselves are but seldom seen, being for the most part concealed by a talus of debris. The base of the series, however, is nearly as well marked as the summit, by the sandstone of the Grey band, which crops out from below them, and forms a low, but distinct terrace. . .

"In several places in the township of Sydenham the thin-bedded limestones of the Clinton formation are seen to rest upon the red and green shales of the Medina. . . .

"In these townships [Collingwood, Euphrasia, St. Vincent and Sydenham], the Clinton formation also spreads out somewhat wider than usual; and the red ferruginous band, which marks the upper part of it, is met with in several exposures, though nowhere sufficiently charged with iron to constitute a workable ore. In the second lot of the fourth and fifth ranges of St. Vincent, in a bed of bluish shale, near the summit of the formation, crystals of gypsum are disseminated in some abundance.

"At Owen Sound the Medina rocks [sandstone] are limited above by about twenty feet of dolomite, which here constitutes the base of the Clinton formation. This dolomite, which is of a yellowish color and weathers yellowish-brown, contains, in great numbers, a few species of silicified fossils. . . Between it and the base of the massive limestones, which are classed with the Niagara series, the surface is covered with red clay. The strata from which this is derived, no doubt, represent the iron ore bed, and are seen in several places within a circuit of three miles. From the bight of Owen Sound, the Medina and Clinton formations are traceable along nearly the whole lake front of the township of Keppel; and in the vicinity of Cape Commodore their entire thickness can be determined by actual measure-

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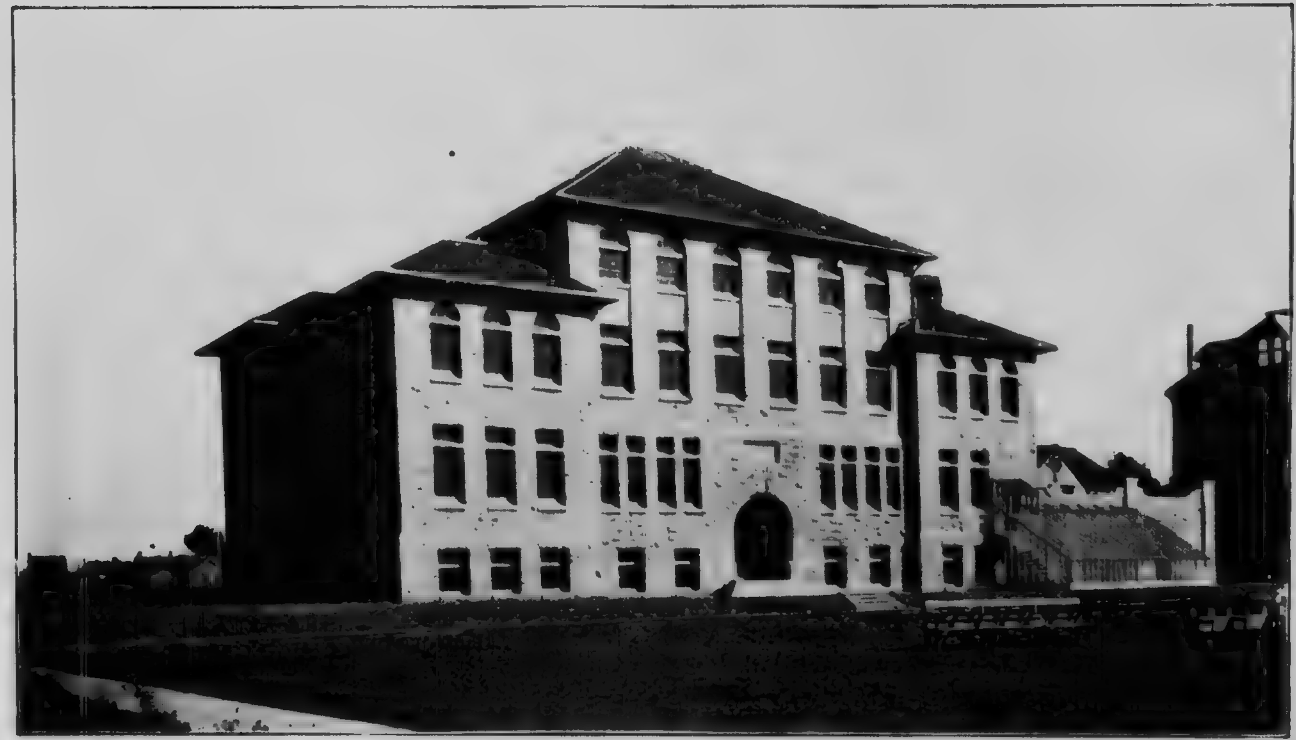
(82) G.S.C., 1896, pp. 62, 63 A.

(83) Ibid. Sum. Rep.. 1899, p. 136-7

(84) G.S.C., 1863, p. 211.



Engineering building, School of Mining, Kingston; built of Kingston limestone. Frontenac County.

Limestone quarry at Dolly Varden siding lime kilns. Halton County.

Lime kilns at Dolly Varden siding. Halton County.

Kelso limestone quarry. Product used in making gray lime. Halton County.

Limehouse: a series of old "set" kilns, with new "draw" kiln on right. Halton County.

Lime kiln at Delta, Leeds County.

Limestone quarry at Beachville. Product used in making lime for building and refining beet sugar. Oxford County.

ment. Strata of the Hudson River formation here constitute the base of the cliff, above which the red and green Medina shales present a volume of 100 feet. Resting upon these, the Clinton formation shows about 36 feet of thin-bedded magnesian limestone, between which and the abruptly overlying escarpment of the Niagara series, there is a thickness of about 150 feet. In this the strata are partially concealed; but a considerable portion of them appear to be red shales. The base of the Clinton appears to cross Colpoy's Bay, at about three and a half miles, and the summit, at about two and a quarter miles, from its western extremity; having a mile and a quarter for the breadth occupied by the formation. From this it would appear that the slope of the strata in this part is about 120 feet in a mile." (85)

Niagara Formation

"The cliffs [of Niagara limestone] continue through Mulmur and Nottawasaga; and on the twenty-fourth lot of the twelfth range of the latter township the whole mass of this limestone to the highest part of the escarpment, has been ascertained by measurement to be about 160 feet thick. As far as seen its color appears to be greyish at the base, gradually passing upwards into buff or yellowish-white; most of the beds being banded with the two colors. The rock, which is magnesian, is harder in the lower than the upper part, and appears to be encrinal for most of the thickness; the encrinites abounding towards the top. It maintains the same colors and characters along what is called the Blue Mountain ridge through Collingwood [township], to the point where the ridge approaches nearest to Lake Huron; and it is probable that the formation thus far does not diminish in volume.

"In the valley of the Beaver River, in Euphrasia and Artemisia, the same limestone has a thickness of at least 120 feet. At the head of the valley, on the 26th lot of the 10th range of Artemesia, the stream falls over a precipice of 70 feet of this magnesian limestone. Flowing thence rather to the east of north, it is flanked on both sides by bold escarpments of the rock, which gradually separate from one another; leaving between them a beautiful and fertile valley, which in a distance of about eight miles attains a breadth of three miles. In several places the escarpment becomes perpendicular, and in a precipice on the right side of the valley, about the 10th lot of the 3rd range of Euphrasia, 47 feet of the rock appear to constitute a single massive bed, without divisional planes. The color of the rock is, as before, a pale buff or yellowish-white, and the weathered parts display obscure encrinites and corals.

"The escarpment on the left side of the valley continues northward into St. Vincent; and then makes a sharp turn to the westward, running for ten miles in that direction on the right or southern side of the valley of Big Head river, which is supplied from it with several tributaries. On the left side of this stream, and between it and Owen Sound, the limestone spreads out into a high flat-topped hill, situated chiefly in Sydenham, and presenting to the north[illegible] a vertical escarpment. The en[illegible] portion of the limestone is well displayed at the summit, while the characteristic Pentamerus oblongus occurs on both sides, at the base in the first range of South Sydenham.

"The two streams which flow into the bight of Owen Sound, the Potawatamie from the southwest and the Sydenham from the south, fall over precipices of 20 and 50 feet respectively, of the lower part of the same limestone; the bottom of which is from 20 to 30 feet beneath the cascades. On the 13th lot of the 2nd range of Derby the escarpment which runs between these two falls presents a height of 60 feet; at the base of which there occurs a bed abounding in corals. . . .

"The rock of the escarpment in this neighborhood abounds in excellent material for the purposes of construction. About two miles south by east from the town of Owen Sound there are unworked strata of a white or pale grey color, of which the upper beds are from two to four feet thick, and the lower ones occasionally over twelve feet. The upper bed might be quarried to an almost boundless extent, and would give a very fine and lasting stone. The lower beds are likewise fit for building purposes, but being at the base of an abrupt precipice, they cannot be so conveniently quarried. Large loose blocks, however, skirt the escarpment, and these would furnish a supply for a great length of time. About a mile and a half up the Sydenham River there has lately been quarried from the lower beds of the escarpment some fine stone for the lighthouse constructed on Griffith's Island. The road south from Owen Sound, on the line between Sydenham and Derby, crosses the base of the limestones, about a mile and a half from the town. After a rather sharp ascent over the lower part of the escarpment, it gradually rises for some distance, and reaches what is considered the summit of the formation, on the 6th lot : the total thickness being about 150 feet." (86)

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(85) G. S. C., 1863, pp. 315-319.

"The bold escarpment formed by the Niagara limestone in Derby appears about two miles west of the town of Owen Sound, and between this position and Colpoy's Bay it sweeps round towards the heights above Cape Commodore, in a line conforming in some degree to the shape of the coast, but presenting a less salient curve. The base of the limestone comes upon Colpoy's Bay, and crosses it, probably, about two miles and a quarter from its bight."(87)

Guelph Formation

"Exposures of these dolomites [of the Guelph formation] are again met with on the Rocky Saugeen River, upwards of forty miles N.W. from Fergus. One of them occurs about three miles beyond Durham, where the Garafraxa and Owen Sound road crosses the river. Here the rock has been quarried for building stone, and for burning into lime The lower part is a light greenish-grey sub-crystalline magnesian limestone, divided into beds of from eight to ten inches thick with very obscure fossils; while the upper part is a greyish-white coralline mass, seven feet thick, in several beds, of which the thickest is 3 feet. . . Another of these exposures is at the junction of the Rocky Saugeen with the main stream, in the rear of the 62nd lot of the 3rd range of Bentinck; where about 25 feet of the rock are seen on the right bank. The upper 12 feet consist of a rough, irregular bed of greyish-white dolomite; underlaid by a buff colored compact stratum, divided into layers of from 3 to 4 inches. . .

"The exposures which have been mentioned between Puslinch and Bentinck belong to the upper part of the formation, and indicate the strike of its summit northward, as far as the Rocky Saugeen. In this region, with the exception of the space occupied by the westward spur of the Niagara series on the Rockwood anticlinal, the Guelph formation presents a breadth of about 25 miles, opposite to Puslinch, which gradually increases to 35 miles opposite to Bentinck. This great breadth is probably due in part to the fact that the country rises with the general slope of the strata, to the edge of the eastern escarpment, though at a somewhat smaller angle; and in part also to a series of north and south undulations, which appear to exist in this region. . .

"From Bentinck northward the strike of the summit of the formation appears to continue in the same bearing as between Puslinch and Bentinck, for about 25 miles, to the Riviere aux Sables (north). The base, however, folding successively over the supposed anticlinals of the Beaver River and Owen Sound, the breadth of the formation becomes reduced, between the latter place and the Riviere aux Sables (north), to ten miles; which is about the same as that which it appears to have between Guelph and Breslau.

"It has already been stated that the strata seen near the mouth of Riviere aux Sables, at Chief's Point, probably strike along the coast by Lyell Island to Cape Hurd, and belong in part to the Niagara formation, whose characteristic fossils are met with in several localities along the shore. These strata, however, have for the most part the lithological characters of the Guelph formation, and some of their undescribed species of Murchesonia have a strong resemblance to others found in this series. . . so that it is not impossible that some of the strata along this coast may constitute a passage between the Niagara and Guelph formation." (88)

The composition of the limestones belonging to the Silurian formations in this county is similar to that of the same strata in Wentworth and other counties. Analyses of Guelph, Niagara and Clinton limestones are given in the descriptions of limestones of other counties. They all carry a fairly high percentage of magnesia.

Marl

Marl deposits are numerous in the counties of Grey and Bruce. "On the 26th lot of the 1st range of Bentinck, a deposit of marl has been traced over 8 or 10 acres of low ground, which is covered with heavy timber. The marl is very solid and pure, and where examined was found to be four feet in thickness." (89)

Following is an average analysis of marl used in the manufacture of cement at the Imperial works, Owen Sound : (90)

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(86) G. S. C., 1863, pp 328-9.

(87) Ibid., p. 331.

(88) G.S.C., 1863, pp. 342-344.

(89) Ibid, p. 764.

(90) Cat. Ont. Min. Exhibit, Buffalo, p. 82.

(1.)	Per cent.
Silica	1.43
Iron oxide	0.18
Alumina	0.20
Lime	50.62
Magnesia	2.09
Ignition loss (carbonic acid and organic matter)	45.58
Alkalies	nil
Sulphates	nil

(2) "From a deposit occurring on lot twenty-four of the ninth concession of the township of Artemesia. . . . The deposit covers about twelve acres, and has a depth of at least seven feet.

"The air-dried material is earthy; slightly coherent; color, yellowish-white. It contains a few shells and some root fibres.

"It was found by Mr. F. G. Wait to have the following composition:

(After drying at 100 de·· C.—Hygroscopic water 0.34 per cent.)

Lime	48.73
Magnesia	0.73
Alumina	0.28
Ferric oxide	0.25
Manganous oxide	traces
Potassa	"
Soda	"
Carbonic acid	38.99
Sulphuric acid	0.06
Phosphoric acid	0.02
Silica, soluble	0.21
Insoluble mineral matter	8.30
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	3.30
	100.87

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 87.02 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of:

	Per cent.
Silica	5.56
Alumina and ferric oxide	2.17
Lime	0.06
Magnesia	0.04
Alkalies	0.47
	8.30

(3) "From a deposit at Shallow Lake, township of Keppel. . . The deposit extends over an area of upwards of five hundred acres, and has an average depth of about six or seven feet.

"The air-dried material is earthy, somewhat coherent; colour almost white. It contains no visible shell remains or root-fibres.

"An analysis by Mr. F. G. Wait showed it to contain:

(After drying at 100 deg. C. Hygroscopic water equals 0.30 per cent.)

Lime	52.52
Magnesia	1.04
Alumina	0.08
Ferric oxide	0.16
Manganous oxide	traces
Carbonic acid	42.47
Sulphuric acid	0.02
Phosphoric acid	0.01
Silica, soluble	0.08
Insoluble mineral matter	1.74
Organic matter, viz., vegetable fibre, in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	2.70
	100.52

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 93.79 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of: (91)

	Per cent.
Silica	1.22
Alumina and ferric oxide	0.32
Lime	0.03
Magnesia	traces
Alkalies	0.17
	1.74"

"Deposits of calcareous tufa occur in many places along the base of the Niagara formation in the counties of Grey and Simcoe. The most considerable known is on the banks of the Beaver River in Euphrasia and Artemisia, which probably covers 1,000 acres. An area of about 300 acres of tufa, with an average thickness of five feet, occurs in a similar geological position at the falls of the Noisy River in Nottawasaga." (92)

Haldimand

The limestone formations—Onondaga, Lower Helderberg or Water Lime, and Corniferous—of this county are briefly described in the following notes:

Onondaga Formation

"The exposures of the Onondaga formation in Canada, so far as yet examined, appear to belong chiefly to the upper portions, from the summit to a little below the gypsum-bearing beds. These portions consist of dolomites and soft crumbling shales, which are greenish, and sometimes dark brown or bluish in color, and are often dolomitic. The dolomites are mostly of a yellowish brown or drab color, and are in beds which seldom exceed a foot in thickness. They often exhibit the vesicular or the lenticular cavities just described. Some beds of a bluish dolomite are also met with; and many of the strata, both above and below the gypsum, contain such a proportion of clay as makes them fit for hydraulic cement.

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(91) G.S.C., 1894, pp. 29-31 R.

(92) Ibid, 1863, p. 804.

"The beds of gypsum are never continuous for long distances, but appear as detached lenticular or dome-like masses; the strata above them being arched over and often broken, while those below constitute an even undisturbed floor. The gypsum is interstratified with the dolomite, and often separted by beds of it. The layers of gypsum may sometimes extend for a quarter of a mile, but they have always been found, on working, to be lenticular in form, and to gradually thin out, until the strata above and below the masses come in contact. This peculiar structure gives rise to mounds on the surface, which are regarded by the inhabitants as indicative of the presence of gypsum beneath.

"Between the Niagara and the Grand River the workable masses of gypsum, if any are present, are concealed by the drift, but on the Grand River they are seen twelve or fourteen miles above its mouth, in the third range of North Cayuga, and thence are traced to Paris. Their strike appears to coincide with the general course of the river. A large deposit of gypsum, which has been extensively wrought, occurs on the land of Mr. Brown, about three miles below the village of Cayuga, on the left bank of the Grand River. It is supposed to extend over at least sixty acres, and is generally covered only by drift. In some parts, however, portions of thin dolomitic beds are found, resting upon the gypsum, which is five feet in thickness and very pure. The lower portion includes some thin interrupted layers of dolomite, which are vesicular when weathered. In a well sunk upon this bed, near the proprietor's house, there were found beneath the gypsum about twenty feet of dolomite, containing small portions of gypsum, beneath which, at the bottom of the well, were three or four feet of unmixed dolomite, fit for water cement. The dip of the bed, which is about S. 20 degrees W. — 2 degrees, would carry it under the level of the river; and the position of the summit of the formation, which is seen at a little distance on the other side of the river, would apparently give a thickness of about ninety or one hundred feet above the gypsum. This upper portion of the formation, as seen in Jones's tract, consists of a dark ferruginous shale, with nodules of yellowish-grey chert; interstratified with greenish marl, containing harder layers. The thickness of these beds is about thirteen feet, and they are surmounted by about five feet of yellowish shale and tufaceous dolomite, with vesicular bands.

"About five miles above Brown's plaster bed, gypsum occurs in Indiana, on the left bank of the river, and about four miles farther, near to York, on both sides. The following is a descending section of the strata observed in the latter vicinity, near Mount Healy, at the plaster bed of Mr. Taylor :

	Ft.	In.
Drab-colored dolomite, with some blue layers, in beds of about five inches..	2	3
Greenish shales...	3	0
Drab-colored vesicular dolomite, yielding good lime..	1	6
Blue thin-bedded hard limestone, said to be fit for hydraulic purposes.	1	7
Pure white gypsum, with bluish bands.....	3	6
Blue schistose argillaceous dolomite, some of it fit for water cement...........	5	0
Grey dolomite, with joints at right angles to the beds, which are thicker at the bottom than at the top, and separated by partings of shale....	6	0
	22	10

"In the bed of the river at York is a stratum of solid limestone, which would underlie the above section: it holds small quantities of galena. The dip of the measures in this part, judging by the strike of the summit of the formation, is, like that of Cayuga, about S. 20 degrees W.; but it is not easy to determine the slope. If we assume the thickness of the overlying portion to be the same as before, the distance of the summit, which is nearly five miles, would give a slope of about 20 feet in a mile.

"Three adits have been opened in this plaster bed at Mount Healy, and afford good opportunities of studying the gypsiferous rocks. One of the most remarkable characteristics is the irregular nature of the bedding. Some of the layers of dolomite immediately below the gypsum, to the east of it, are seen to augment and to then diminish considerably in thickness in the distance of a few feet; giving thus, at first sight, the appearance of undulations, while the beds beneath are completely horizontal. In the central opening, a layer of dolomite, not seen in the others, is interstratified with the gypsum; and in one of the adits, the gypsum bed is observed to thin out, the strata from above bending downwards, and conforming to it. It results from these irregularities in the beds that sections in different portions are by no means concordant. In one part three or four feet of dolomite overlie the gypsum bed, the upper part being vesicular, and a portion of it filled with crystalline carbonate of lime. Here, immediately resting upon the gypsum, is a reddish ferruginous layer, followed by two inches of green shale. In another opening, this thin layer of shale is succeeded by a few inches of plastic calcareous clay; to which succeed very thin bedded vesicular dolomites, whose surfaces are marked with the branching lines already described. Farther on, this layer of shale becomes a foot or two in thickness; and it includes portions of travertine, which is sometimes compact like alabaster, and forms considerable masses in the fissures of the overlying beds. At about three feet above the principal mass of gypsum, a second interrupted layer is met with, which is very pure. It is generally only a few inches thick; but it swells to a foot or two in some places, and in others is wanting.

"At Aikman's plaster bed, a mile and a half above York, on the left bank of the Grand River, the mass of gypsum is seven feet in thickness, but is divided into six layers by interstratified bands of dolomite, of from two to six inches; the same band varying in short distances. The upper portion of gypsum is two feet thick, and is pure and white: the lower portions are mixed with dolomite and are less pure. Immediately above the gypsum is a sandy ferruginous layer of from two to six inches: then after some layers of dolomite, occur eighteen inches of greenish shale, followed by four feet of yellowish vesicular dolomite. For the next two miles, as far as Seneca, the gypsum appears occasionally, in thick rounded masses, enveloped and underlaid by green shales, the lower portions of which sometimes include small interrupted layers of the mineral.

"About two and a quarter miles across the measures, in a direction nearly S.W. from Seneca, there is an exposure at McKenzie's mills, of about twelve feet of beds belonging to this formation, which may be fifty or sixty feet higher in the series than the gypsum. The section consists of drab-colored dolomite, sometimes vesicular, interstratified with hard blue slaty layers, and with green shales; which sometimes include thin dark-colored laminae. The same strata are met with again at Barton Creek, about a mile south from McKenzie's mills. Some of the beds at both places yield good lime, but others are unfit for burning." (93)

Lower Helderberg

"The third locality in which characteristic fossils of the Lower Helderberg, or Water Lime, formation have been found, is at Rattlesnake falls, on a small tributary of the Grand River, on the thirty-fifth and thirty-sixth lots of the first range, south of the Talbot road, in Cayuga, where a series of beds occurs, very much resembling those of Jones's tract [see under Welland county], but showing not more than half the thickness." (94)

Corniferous Formation

"Many of the beds [of the Corniferous formation], contain silicified organic remains. These, in some localities, as in North Cayuga, and at Port Colborne, are found weathered out and loose in great abundance, at the surface of the ground. Some of the beds are little more than an aggregate of silicified organic remains, with so little calcareous matter that the whole mass coheres, after the carbonate of lime has been dissolved out. The Corniferous limestones, unlike the great mass of the Middle and Upper Silurian strata in Western Canada [Ontario], effervesce freely with acids, and are not dolomitic. . . .

"To the west of the Grand River, in the counties of Haldimand and Norfolk, the Corniferous limestones are often seen resting on the Oriskany formation, and forming small eminences, which present escarpments, with the sandstone at their base. These limestones are here of a drab color, and abound in chert. The organic remains with which the strata abound are entirely silicified in many of the beds, while in others they have undergone no such change. . . .

"Higher in the series, along the same line of country, blue limestones, sometimes to the amount of 20 feet, with grey beds in less volume, are associated with chert layers, and interstratified with bands of a drab-colored limestone. These strata are sometimes quarried, and yield stone fit for building purposes." (95)

(93) G.S.C., 1863, pp. 347-9

(94) Ibid. pp. 354-355

(95) Ibid. pp. 368-371

Quarries

"On the bank of the Grand river, four miles south of Cayuga, my brothers own a quarry. It is a limestone, but is magnesian, and is not good for lime. Under that bed there is a layer of stone that could be manufactured into cement. Some years ago a quantity was burned in an ordinary lime-kiln. Only a few barrels were made, but it worked as well as the Thorold, and very much like it. The stone is grey and brown in color; a considerable quantity was quarried as building stone, and they get blocks from twelve to fifteen inches thick; it has been used at Dunnville. The quarry extends along the bank of the river about half a mile. The stone does not stand the weather as well as the sandstone; it is more liable to crumble. About three miles from Ridgeway there is Corniferous limestone. It is extensively used in making lime, and makes a first-class article, very white and about the same quality as the Beachville lime." (96)

"A third excellent exposure in this vicinity is at Teitz' quarry, lot 1 in the fourteenth concession of Walpole, which probably lies at a higher horizon than either of the preceding. About ten feet are exposed of roughly-bedded limestones with numerous fossils, which are in some respects different from the assemblage at the two other quarries. Some species are found here which are rare or quite absent from the previously described deposits.

"At Springvale, lot 6 in the fourteenth concession of Walpole, outcrops an even bedded non-fossiliferous limestone showing glacial striae west-southwest on the surface. The heaviest beds are eight to ten inches thick and of a whitish gray color. Below the level of the quarry the rock is said to be a blue limestone, but this requires confirmation. The non-fossiliferous limestone shows increasing silica on descending. The average lime made from the rock has hydraulic properties and requires about 16 to 1 of gravel to make a durable cement. (97)

Analysis:

	Per cent.
Moisture	0.15
Silica	3.60
Alumina	2.20
Ferric oxide	1.89
Calcium oxide	31.08
Magnesium oxide	17.79
Ignition loss	44.73

"Overlying this and a few rods west of the exposures are beds of Oriskany sandstone six to eight feet in thickness. . . .

"The fossils, with the exception of the ganoid fragment, are mostly casts, the calcareous matter of the shell having been dissolved. Two sorts of stone are quarried from this exposure, an extremely hard variety with silicious cement which may prove useful for grindstones and for refractory purposes, and a soft friable example possessing insufficient coherence to make a satisfactory building stone. Above the sandstone, towards the northwest corner of lot 6 in the fourteenth concession of Walpole, is a ridge of Corniferous rock, presenting the characteristic fossils of the coralline beds and many fragments of trilobites. . . .

"Southwest of these deposits, on the farm of Elias Shoap, lot 9 in the thirteenth concession of Walpole, is an excellent exposure, showing 20 feet of vertical section. The upper strata consist of about ten feet of thin-bedded fossiliferous cherty limestone with corals predominating, as at Rockford. This is underlaid by five feet of soft sandstone as at Springvale, while the bottom five feet consist of hard indurated sandstone with silicious cement.

"But occasional small outcrops are seen from this point to Hagersville, where are situated some of the most extensive quarries in the district. Glacial striae west-southwest are observed on the surface rock. The upper ten feet of this section show the cherty coralline limestone with a predominance of favositoid corals, below which lie six or eight feet of more heavily bedded and less fossiliferous stone of excellent quality for building purposes. Underlying this layer are two feet of stone, which is practically all flint, and is succeeded by five feet of good blue limestone, giving the following analysis (98):

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(96) Hon. J. Baxter in Roy. Com., 1890, p. 55.

(97) A sample of the lower flinty layer in the lime kiln at Springvale was collected by the writer. Mr. Burrows found it to have the percentage composition given in column 1. Another general sample from this quarry had the composition shown in 2:

	1.	2.
Moisture	.90	.....
Insoluble residue	1.00	23.24
Alumina	trace	1.28
Ferric oxide	.02	1.10
Calcium oxide	30.26	39.04
Magnesium oxide	20.80	1.17
Carbon dioxide	46.62	31.78
Sulphur trioxide	.93	.15
	100.53	97.76

(98) Samples collected by the writer at the Hagersville quarry were found to have the following composition:

	1.	2.	3.
Insoluble residue	16.50	12.68	4.78
Ferric oxide	.94	.72	.92
Alumina		.28	.22
Lime	41.92	44.00	46.52
Magnesia	.67	3.77	4.85
Sulphur trioxide	.32	.18	.41
Carbon dioxide	31.37	38.66	41.42
Moisture	5.28	.....	.60
	100.00	100.27	99.72

1, lower 3 ft. of quarry; 2, lower layer at the northeast corner of the quarry; 3, above lower 3 ft. of quarry face.

	Per cent.
"Moisture	0.24
Insoluble residue	5.32
Ferric oxide	1.21
Alumina	3.00
Lime	45.14
Magnesia	1.64
Carbonic acid	35.46
Loss on ignition	40.89

"The writer is informed that a drill hole 87 feet exposed nothing but continuous limestone. Most of the product of these quarries is made into rubble, in which an extensive trade is carried on. The percentage of silica has the effect of rendering the rock rather hard, and somewhat impairs its value as a building stone on account of the added difficulty of chiselling.

"Two miles south of Hagersville, at the 'Gore,' the soft sandstones of the Oriskany crop out, underlaid as usual by the smooth non-fossiliferous limestone.

"Following the road from Hagersville to Cayuga, the first exposures are of the hard cherty limestone seen at the cutting of the M.C.R. This rock underlies the sandstone and separates it from the "waterlime"; it was not observed at Springvale and does not appear to be continuous. The Oriskany sandstone reaches a thickness of 15 feet in this vicinity, and shows distinct traces of glaciation in a west-southwest direction. The rock itself is more compact and of better grain that that at Springvale, and is quarried at several points along the road. The above mentioned chert is absent at many points, the sandstone being directly succeeded by the smooth limestone, an average analysis of which gives :

	Per cent.
"Water	0.35
Silica	3.44
Alumina	2.34
Ferric oxide	1.86
Calcium oxide	26.61
Magnesium oxide	17.47
Ignition loss	44.96

"On lot 40 in the fourth concession of North Cayuga, this lime rock is again exposed where a quarry has been opened by Mr. J. Best. The upper ten feet consist of the even-bedded gray non-fossiliferous limestone, while the lower part shows the same lack of fossils but is of a bluish hue, and capable of being quarried in larger blocks. The analysis of this rock is as follows :

	Per cent.
"Water	0.55
Silica	4.14
Alumina	26.60
Ferric oxide	1.56
Calcium oxide	20.09
Magnesium oxide	14.51

"The unusually high percentage of alumina is remarkable; this rock might well be used to enrich others in the vicinity whose content of alumina is too low for the best results in the manufacture of hydraulic cements. The surface of the rock at this quarry shows distinct glacial striae running west-southwest. The overlying soil is heavy boulder clay. On lot 36 I.S. of North Cayuga, the valley of denudation of Rattlesnake creek shows an excellent section of these lower beds, about 30 feet being exposed. The upper portions consist of the non-fossiliferous waterlime beds, separated by shaly layers, while at the bottom of the section bluish, friable limestones crop out. Much of this stone is fine-grained and very uniform; it should afford examples suitable for lithographic work.

"We have therefore in this vicinity thirty or forty feet of the so-called waterlime belonging to the Lower Helderberg series resting on a shaly blue limestone and covered in places by a narrow bed of chert, or where this is absent, succeeded directly by the Oriskany sandstone showing a maximum thickness of twenty feet. Close above the sandstone are the coralline layers of the Corniferous, which is attested by the fact that in many of the fields surrounding the sandstone exposures, fossils of this type may be collected. . .

"From this vicinity southward to Cayuga no more exposures are encountered, the rock being hidden beneath a uniform bed of clay. South of this town outcrops are well known, but the expedition was not carried so far." (99)

The Hagersville quarry, operated by the Hagersville Contracting Company, is situated near the town. The stone makes good road material and is used chiefly for this purpose and for concrete. The quarry has a depth of about 12 feet and covers a considerable area. The upper layers contain silicified fossils and chert nodules which add to its value as a road material, but the lower three and one-half feet is pretty free from fossils, and has been used by the St. Thomas car wheel works as a flux. The crushing capacity of the plant is about 400 tons a day. In summer 80 or 90 men are employed. In winter the force is less. Shipments are made by the Michigan Central and Grand Trunk railways. The crushed stone is shipped as far west as Windsor. The color of the beds in

(99) B. M., Vol. XII., pp. 145-7

the quarry is dark gray to blue.

A small lime kiln is operated at Winger's quarry, Springvale. Hitching posts for horses are also made from the lime and crushed stone. About 9 feet of rock are exposed in the quarry. The upper 3 feet of rock is soft and breaks irregularly. The lower layers are brittle and break with a flint-like fracture. The stone is fine-grained.

The dip of the beds, which is slight, appears to be westward or southwestward. Limestone comes to the surface at the corner of the road at Gill P.O., and between this point and Hagersville.

What is known as Decew's sandstone quarry lies near the road about 2 miles northeast of Gill P.O., and about 5 miles from Hagersville. The face of the quarry is 12 to 15 feet in height. The rock is thick bedded, massive, medium grained, rather friable, gray-weathering sandstone. On fresh surfaces it has a light reddish color. The lower bed, as it lies in place, appears to have a thickness of about 6 feet; and the upper ones are nearly as thick. To the south rather thin-bedded limestone underlies the sandstone. This limestone is fine grained, soft and appears to be argillaceous. The overlying sandstone, which outcrops on the road, but rises little above the level of the surrounding country, thins out rapidly to the southward. The sandstone represents the Oriskany formation, and the underlying limestone belongs, apparently, to the Water-lime series. A sample of this limestone was taken for analysis, and was found to have the following composition:

	Per cent.
Silica	1.58
Ferric oxide	1.25
Alumina	.10
Lime	30.18
Magnesia	19.78
Carbon dioxide	45.35
Sulphur trioxide	.13
	98.37

The following analyses show the composition of some argillaceous dolomites from this county:

	1.	2.	3.
"Carbonate of lime	39.91	51.33	25.20
" of magnesia	34.15	40.91	19.70
Argillaceous residue	22.10	5.50	52.20
Water	3.84	2.26	2.90
	100.00	100.00	100.00

"The first two analyses are by Delesse; 1 is a dark earthy rock, from Martindale's gypsum quarry at Oneida; 2 is a specimen of the vesicular dolomite, brownish-yellow in color, from the gypsum quarries at Paris, on the Grand River; and 3 is a greenish crumbling shaly rock from the same locality." (100)

Haliburton District

The character and distribution of the crystalline limestones of this district are described in the following notes:

"The study of the Grenville series in Monmouth, showed beyond a doubt that this series is a sedimentary one. It includes a great development of bedded white quartzites, evidently altered sandstones. The associated limestones also, that occur in heavy bands, and, as everywhere else in the Grenville series, are in the form of white crystalline marbles, were in a few places along the line of the Irondale, Bancroft and Ottawa railway, seen to hold little dark strings suggestive of remnants of the original limestone in a less altered condition. On this account, a careful search was made, which resulted in the discovery of two localities in which the limestone was almost unaltered, being very fine in grain and blue in color, and bearing a strong resemblance to the limestones of more recent formations. In such cases the blue limestone is interstratified with the ordinary white coarse-grained marble of the Grenville series and passes into it, there being evidently portions of the limestones which have escaped metamorphism. These occurrences serve to dispose of any lingering doubts concerning the sedimentary origin of the limestone in question. The localities where these unaltered limestones are best seen are lot 27 of range 14 of Monmouth and lot 28 of range 11 of the same township." (101)

"In the southern and eastern portions of the sheet the Laurentian contains an abundance of crystalline limestone and has all the characters of the Grenville series of Sir William Logan, in which series, as is well known, nearly all the mineral deposits of economic value occurring in the Laurentian in Quebec and Eastern Ontario are found. In the north-western portion of the area on the other hand our explorations have so far failed to discover any crystalline limestone, the country being apparently occupied by gneiss alone. As townships in which this crystalline limestone is especially abundant, Lutterworth, Minden, Snowdon, Dysart, Glamorgan, Monmouth, Cardiff and Brudenell may be mentioned, as well as the township of Galway lying to the south of the area embraced in sheet 118.

"The discovery of so large an area of the Grenville series in this district is most encouraging, as indicating the probable occurrence in it of large and valuable mineral deposits.

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(100) G.S.C., 1863, p. 625.

(101) Ibid, Vol. XI., 1898, p. 109 A.

"The relation of the Grenville series, in this district, to the rest of the Laurention which is free from limestone, has not as yet been definitely determined, although the limestones and their associated gneiss seem in certain cases to partially inclose areas which contain no limestone. Another noteworthy fact is that throughout the area occupied by these Laurentian rocks, the dip is uniformly in an easterly direction, usually at moderate angles. Only at one or two points have westerly dips been observed, and these are quite local." (102)

Lutterworth Township

"In this township there is an abundance of excellent crystalline limestone, especially in that part of it which lies to the east of Gull Lake. Much of this is very pure and constitutes a veritable marble, as on lots 19 of ranges 4 and 5, and on lot 20 of 5, while elsewhere it contains grains of hornblende, mica, serpentine and other minerals scattered through it. This limestone would yield excellent lime, and could also be employed for building purposes if sufficiently accessible. It is, however, rather coarse grained for very fine work or for statuary.

"There is a local tradition that silver was formerly mined at Miner's Bay on the east shore of Gull Lake. No workings are known to exist, however, and no ore is ever known to have been discovered in the vicinity. A little molybdenite in flakes and crystals was found in the gneiss at this locality. This may, on account of its silvery appearance, have been mistaken for an ore of silver.

"Molybdenite disseminated through crystalline limestone also occurs on lot 23 of range 5.

"Graphite was observed in small quantities in the gneiss and limestone at several localities. I am informed that it occurs more abundantly on lot 15 of range 4.

"A deposit of iron ore on lot 5 in the northern part of range 5 and the southern part of range 6 of this township, was at one time worked quite extensively, several hundred tons of ore were extracted and shipped, but work was discontinued seven or eight years ago. Two large openings and several small holes have been excavated in the deposit, but are now for the most part filled with water. The country rock is a reddish gneiss, interstratified with many small amphibolite bands, as well as with a small band of crystalline limestone" (103).

"There is a great deal of very good marble through the Haliburton country, of the ordinary white crystalline variety. It is both in Snowdon and Glamorgan, and some variegated has been obtained from 17 in the 1st concession of the latter township. Some has been polished that came from Galway, and some taken from lot 32 in the 5th of Snowdon has been used for monumental purposes" (104).

Halton

"The strata of this section [Medina and Clinton] are limited by a bold escarpment, composed of the rocks of the Niagara formation, which succeeds. By this escarpment they are easily traceable from Flamborough West, in a northeasterly direction, through Flamborough East into South Nelson. On entering the latter township they take a sweeping turn northward, and maintain a general course somewhat westward of north, for 75 miles, from South Nelson to Collingwood." (105)

"Northward from Flamborough East, the massive beds of encrinal limestone, [see section given under county of Wentworth], which pass below the cherty band, form the crest of the lower escarpment, and appear to gradually increase in thickness in that direction. . . . On the seventh lot of the seventh range of Nassagaweya there is a vertical precipice, in some places a hundred feet in height. It is capped by the encrinal band, while the Pentamerus bed is probably at the base; but though the stratigraphical place of the black shale would thus be in the cliff, it has not yet been detected. Nearly the whole mass of rock appears to be a light grey, drab-weathering limestone, usually presenting a black surface in the cliff, from the presence of minute lichens. Much of it appears to be magnesian, and it for the most part abounds in encrinites. It is well adapted for building purposes, but it seems too porous to be made available as a marble. Some of the beds are well adapted for burning to quick-lime, and these probably contain a smaller proportion of magnesia. Though the very base of the limestone is concealed by a talus of debris, its near proximity is indicated by the copious streams of water which flow along

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(102) G.S.C., Vol. VI., 1892-93, p. 4 J.

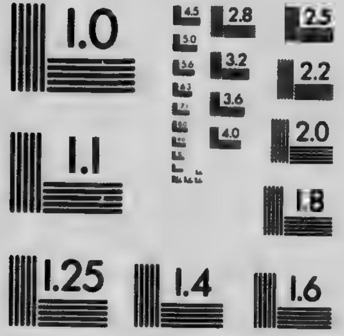
(103) Ibid, p. 8 J.

(104) J. B. Campbell in Roy. Com., 1890, p. 83.

(105) G.S.C., 1863, p. 315.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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its whole outcrop, from the more argillaceous beds beneath, and issue from among the debris; depositing in their course, large quantities of calcareous tufa.

"In a cutting of the Grand Trunk Railway at Limehouse, on a tributary of the Credit, on the twenty-first lot of the sixth range of Esquesing, the base of the Niagara limestone is seen resting on the beds of the Clinton formation. This has there a thickness of only 34 feet; not much more than one-third of what it presents in Flamborough West. It consists of 10 feet of a bluish shale, resting on the Grey band as a base, and overlaid by 7 feet of red shale, which represents the iron ore bed [i. e., the summit of the Clinton]. To this succeeds eight feet of bluish shales, followed by nine feet of water-lime This bed of water-lime rests on a thin bed of arenaceous shale, with a thin seam of reddish sandy clay holding crystals of iron pyrites, and supports a light grey partially magnesian limestone, belonging to the Niagara series, of which only 27 feet are exposed in the cutting. The characteristic Pentamerus oblongus has not been seen here" (106)

"Proceeding northward, the upper escarpment of the Flamborough West section is found to merge into the plain above, and disappears. Black shales and limestones, such as occur in it, are however met with in the sixth range of Nassagaweya, on the Grand Trunk railway, between three and four miles back from the edge of the lower or main escarpment. It is probable that the whole formation is carried westward, in a narrow spur, on the axis of a small anticlinal." (107)

"At Limehouse, in Esquesing, there is a band of nine feet [of water lime], which is wrought to a considerable extent, and yields a good hydraulic lime." (108) This band is in the Niagara formation, but is not supposed to be the equivalent of the Thorold band.

Analyses

(1) "Dolomite, from Limehouse, township of Esquesing. . . .This stone occurs in a band nine feet thick, in beds varying from three to seven inches. Geological position—Clinton formation, Silurian. Collected by Dr. R. Bell.

"A bluish-gray, yellowish-brown weathering, very fine crystalline, compact dolomite. Its analysis afforded the following results:

(After drying at 100 degrees C.—Hygroscopic water, equals 0.27 per cent.)

Carbonate of lime			48.07
" magnesia			39.63
" iron			0.69
Sulphate of lime			0.10
Alumina		0.21	11.60
Silica, soluble		0.37	
Insoluble matter, consisting of:			
Silica	7.60	11.02	
Alumina	2.07		
Ferric oxide	0.40		
Lime	0.05		
Magnesia	0.19		
Potassa	0.53		
Soda	0.18		
			100.69

"This stone has been wrought to a considerable extent, and yields a good hydraulic lime. The cement sets slowly and hardens during several weeks, after which it is said to possess great strength." (109)

(2) "Dolomite, from a quarry at Christie's Siding, west half of the third lot of the sixth concession of the township of Nassagaweya. . . Geological position—Niagara formation. Silurian.

"A light bluish-gray, fine-crystalline, massive, dolomite. Its analysis afforded the following results: (110)

(After drying at 100 degrees C.—Hygroscopic water, 0.10 per cent.)

Carbonate of lime	54.12	
Carbonate of magnesia	45.45	
Carbonate of iron	0.58	
Sulphate of lime	0.17	
Alumina	trace	0.30
Insoluble matter	0.30	
		100.62 "

Among the lime kilns in this county are those of Messrs. D. Robertson & Co., which, together with the quarries, are situated on lot 4 in the seventh concession of the township of Nassagaweya. The two kilns have a capacity of 33,000 lbs. each per day. The lime is used over a large part of the Province, going as far east as Peterborough. The company furnish the following analysis of their lime:

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(106) G.S.C., 1863, p. 327.

(107) Ibid, p. 330.

(108) Ibid, p. 806.

(109) G.S.C., 1895, p. 16 R.

(110) Ibid, p. 17 R.

Lime (calcium oxide)	60.08
Magnesia	35.67
Silica	.20
Iron oxide	1.34
Carbon dioxide	2.71
	100.00

The limestone burned to produce this lime would contain about 33 per cent. of lime and about 20 of magnesia, which represents a slightly higher percentage of calcium carbonate and a slightly lower percentage of magnesium carbonate than is given in the preceding analysis from Christie's siding.

Hastings

The limestones of this county are varied in character and are found in large outcrops in numerous localities. Many crystalline varieties are found in the Grenville or Hastings series of the Laurentian system. Attempts have been made to work these as marbles at several places. These are described in following pages.

Dimension stone of large size is furnished by the quarries in the Trenton group at Crookston, and formerly at Point Ann, near Belleville. A cement plant is now under construction at the latter place, the limestone being of suitable character for use in the manufacture of Portland cement.

The Trenton or Black River formation furnishes excellent building stone in many places, and the lithographic layers which are found in it near the village of Marmora and elsewhere have attracted considerable attention.

Marl deposits are known to occur in many localities. The deposit at Marlbank on the line of the Bay of Quinte Railway has been worked for a number of years to furnish material for the cement plants at Marlbank and Strathcona.

Many descriptions of the limestones of the county are to be found in the reports of the Geological Survey, from which several of the following extracts have been taken. The reader is referred to these reports for further details.

Trenton Group

"Turning westward the two escarpments [of the Trenton group] take a course somewhat parallel with Clare River, to Sugar Island on the south side of Stucco Lake, but the lower occasionally crosses to the north side on the way. On the east side of the Moira River the escarpments are more widely separated than hitherto, the lower occurring about a quarter of a mile, and the higher 5 miles down the stream from the lake. On the west side, the second escarpment rises abruptly from the river in the third range; the beds of the lower deposit are cut nearly in two, upwards of a mile from the river, by a projecting ridge of gneiss, which extends for 3 miles to the southwest from Stucco Lake. At the termination of this Laurentian spur on the third lot of the fifth range of Hungerford, an escarpment rises about fifty feet high in nearly horizontal strata. The lower beds, exposed at a distance of about a hundred yards from the gneiss, consist of pale bluish drab calcareous rock, without fossils, and may belong to the lower deposit; while the strata at the summit are dark brownish-grey or blackish limestone, in pretty regular courses of from two to three feet thick, holding Leperditia and some small univalves.

"Below Hungerford Mills, on the twelfth lot of the tenth range of Hungerford, which is on the northwest side of the Laurentian spur, strata are exposed at the edge of the river, which must be near the base of the lower deposit. They are in ascending order, as follows:

"Dark blue limestone, 7 inches.

"Drab-colored limestone of very fine texture, in courses of 3 inches thick, supposed to be fit for lithographic purposes, 9 inches.

"Red arenaceous limestone, passing into calcareo-arenaceous shale at the top, 8 inches.

"Grey limestone, 4 feet. Total, 6 feet.

"Professor Chapman of Toronto states that in the red calcareo-arenaceous rock of this place there is between forty and fifty per cent. of magnesian carbonate of lime. The lowest and nearest Silurian dolomite to the eastward, of which the horizon is certain, belongs to the Calciferous, and this fact would rather strengthen the evidence afforded by the Piloceras at Kingston Mills as to the age of the Hungerford strata. . .

"At the lower end of Hog [Moira] Lake on the south side, on the nineteenth lot of the thirteenth range of Huntingdon, beds very nearly corresponding in character with those of the Hungerford section form a low cliff close to the beach. The same rock appears to form the base of several outlying Silurian patches in Madoc, and to be traceable to Marmora.

"The section at the Marmora iron works, on the bank of the Crow River, is in ascending order as follows:

"Shaly limestone, filling depressions in the surface of contorted Laurentian gneiss, which contains beds or veins of fine-grained syenite; 1 foot.

"Red sandstone, soft and calcareous; the color is deep red in the divisions of the beds, and lighter towards the middle of them; one or two thin interstratified layers are greenish; 8 feet 3 inches.

"Yellowish-white compact limestone of a character fit for lithography. This increases to four inches about twenty yards to the N.N.W. in the strike, where however it appears to have too many crystals for lithographic purposes. It has rough slightly dentated interfitting surfaces, with a greyish-brown film between in some parts; it has also small light green and some dark olive green patches; 1 inch.

"Greenish calcareo-arenaceous shale, spotted with red, with a few quartz pebbles, and a few cavities, as if calcareous pebbles had been worn out of them. At the top there is a thin layer of snuff-brown earth, probably manganesian, passing into green shale; 3 feet 5 inches.

"Mottled grey and greenish-white argillaceous limestone, slightly bituminous; 1 foot 5 inches.

"Dark grey bituminous limestone, somewhat shaly in part; 2 feet.

"Light grey compact slaty limestone; this would probably form good building stone; it is strong and very even, but rather thin bedded; some of it appears fine enough for lithography, 2 feet.

"Light brownish-grey compact limestone in a single bed; this is apparently fine enough in texture for lithographic purposes, but not of the right color; it has a small quantity of bitumen in it. Though seemingly one bed, it splits apart in some places, and shows surfaces with short tooth-like interfitting columnar projections, having a thin film of bituminous matter between; 1 foot 7 inches.

"Light brownish-grey calcareous shale, the last inch and a half becoming a hard limestone in an even bed; 10 inches.

"Light brownish-buff compact very fine limestone, the grain wholly impalpable; the lower half is more homogeneous than the upper, which holds thin lenticular crystals of calcspar; the upper inch, which is just above the part holding most crystals, fits upon [illegible] tooth-like projections of a marked character, the projections having columnar sides at right angles to the bed, an inch long in some places; a thin film of bituminous shale darkens the surface; in the lower part there are obscure tooth-like divisions. This is the Marmora lithographic bed, the best stone being in the lower portion. When exposed to the weather, this part is generally affected by gash-like cracks, which appear to terminate both ways, and run in two general directions, dividing the mass into rhombodial forms; but there are other gashes which run at a small angle to these; the stone weathers nearly white; 2 feet.

"Light grey limestone; the fracture is conchoidal and slightly scaly; the stone is strong and tough, and it would make a good building stone. It weathers slightly yellowish at the joints and bed divisions; the beds are from three to four inches thick, but aggregated beds of a foot and more occur; some of them separate in tooth-like projections, with a film of bituminous shale between. Large slabs may be obtained, some of them six feet square; some of the surfaces are waved; 5 feet.

"Light greyish-brown compact smooth limestone, weathering into gashes like the lithographic stone, and more divided into joints than the bed below; 2 feet 2 inches.

"Brownish-grey compact limestone, rather lighter in color than the previous bed, with lenticular crystals of calcspar; this would make lithographic stone were it not for the crystals; 7 inches.

"Brownish-buff compact limestone, with a conchoidal fracture; there are lenticular crystals of calcspar in the bed, but much smaller than those of the previous layer. This might yield lithographic material; it is doubtful, however, whether the crystals are not too numerous; 7 inches.

"Darkish grey very compact limestone, with a conchoidal fracture; 5 feet 8 inches.

"Measures concealed, 5 feet. Total, 41 feet 7 inches.

"These beds, in which no organic remains have been detected, are succeeded by about forty feet of limestone, having much the same lithological characters, in which fossils are sufficiently abundant, though many of them are obscure. Those which have been recognized belong to the Birdseye and Black River formation. In this section there appears to be such a passage from the arenaceous beds at the bottom to the compact limestones, which become fossiliferous at the top, as to induce the supposition that the whole belong to the formation named, notwithstanding the two Chazy species found at Vanluvin's mills. The rock of Kingston, which appears to be nearly destitute of fossils, presents many intances of the columnar structure so prevalent at Marmora. It frequently contains small masses of yellow blende. Geodes holding sulphate of strontium occur in the limestone at Kingston and near Sydenham, but these minerals have not been met with in what is considered its equivalent to the westward." (111)

Following are analyses of samples of lithographic stone from the quarries on the south side of Crow lake.

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(111) G.S.C., 1863, pp. 179-183.

Marmora village :	No. 1.	No 2.
Insoluble silicate	3.71	3.60
Organic matter	0.40	1.29
Calcium carbonate	89.98	88.03
Magnesium carbonate	2.78	2.50
Soluble silica	0.73	0.49
Alumina		0.57
Ferric oxide	0.15	0.35
Ferrous oxide	0.10	0.04
Water	1.25	1.36
Total	99.10	99.23

No. 1, Light blue gray stone. Sp. gravity at 15.5 degrees, is 2.85.

No. 2, Dark blue stone. Sp. gravity at 15.5 degrees, is 2.89.

"The dark blue variety. . . is from a layer about 70 feet below the general surface of the country near Marmora, showing at the borders of Crow lake. Here some 50 feet of the overlying strata have been broken and washed away. . . Of some 27 layers examined by me only one gave encouraging results, and this is the dark blue variety, analyzed by me as above." (112)

Quarries

"I am interested in four quarries, two in North Hastings, one in Hungerford, and one in the township of Madoc. We obtain from all the quarries valuable stone for building and other purposes. The quarry in the township of Madoc is commonly known as the Victoria or McKinnon. It extends over 40 acres, and contains excellent building stone from three to fourteen inches in thickness, and in some parts of the quarry in layers of two feet in thickness. The stone is easy to take out, is hard and firm, and partakes somewhat of the nature of a lithographic stone; part of it might be used for that purpose. The property is quite convenient to the North Hastings railway, and some 300 or 400 carloads were shipped this year, part being used for the foundation of the new Parliament Buildings at Toronto. It has also been used in many of the principal buildings of that city and has given satisfaction. The Hungerford quarry is on lot 10, in the 9th concession, and quite near to the Crookston station of the North Hastings railway. The quarry was opened last summer. The stone is a firm and fine-grained [Silurian] limestone, and occurs in layers from 16 inches to four feet in thickness. It is well adapted for heavy buildings, railway bridges, etc. Messrs. Manning & McDonald, the contractors, are getting the stone from this quarry for the bridges across the Don." (113)

There are now two quarries at Crookston, the one adjoining the other. That of Messrs. Quinlan & Robertson has an opening of about 600 x 200 feet, and that of Senator Gibson 800x300. In the former quarry five layers of stone are worked. The bottom layers are said to be harder, but the stone from all the layers takes on a uniform color when aged. A sample of dressed stone at the quarry measured 32 inches. About 70 men were employed in each quarry at the time of my visit, of whom 32 in the first-mentioned quarry were stonecutters. Stone was being gotten out for use in construction of power plants at Niagara Falls. The quarries are alongside of the North Hastings branch of the Grand Trunk railway, and about one-quarter mile from the Canadian Pacific. Switches from both roads run to the quarries.

Following are analyses of Palæozoic limestones from working quarries :

PALÆOZOIC LIMESTONES

	1	2	3
Silica	3.42	1.76	3.60
Ferric oxide	.82	1.05	1.25
Alumina	.52	.34	.71
Lime	52.22	51.58	48.48
Magnesia	.72	2.11	3.65
Carbon dioxide	41.53	42.77	41.81
Loss	.21	.23	....
Sulphur trioxide	36	.14	.08
Alkalies	32	......	....
Total	100.12	99.98	99.58

1. General sample from the Crookston quarries. Individual beds probably contain less silica and more lime than is shown in the analysis. 2. Sample from McIntosh's quarry, near Madoc. 3. McKinnon's quarry. These three quarries are referred to in the text.

Samples from Point Ann show the following composition :

POINT ANN, BELLEVILLE.

	1	2	3	4	5	6
Silica	1.64	1.80	....	.47	.60	.80
Ferric oxide	.53	.71	.71	.55	.78	1.02
Alumina	21	.43	95			
Lime	54.06	53.46	51.80	55.01	54.67	54.31
Magnesia	.55	.64	.53	.40	.54	.65
Carbon dioxide	42 90	42 60	41 10	.	....	....
Loss	10	1.00	....	......	....	....
Sulphur trioxide	.41	....	....	......	....	....
Insol. residue	......	....	5.56	......	....	....
Total	100.40	100.64	100.65	....	....	....

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(112) B.M., Vol. II., p. 183.

(113) A. A. McDonald, in Roy. Com., 1890, p. 80.

Samples 1 and 2 are from the chip piles, refuse from trimming stone, at the Point Ann quarry. Sample 3 was was taken from the face of the railway cut on the quarry grounds. The residues insoluble in hydrochloric acid in 1 and 2 were equal to 2.42 and 2.70 per cent. respectively. The silica contained in these residues is shown in the analyses. The silica in the residue in 3 was not determined. Analyses 4, 5 and 6 are taken from the prospectus of the Belleville Portland Cement Company, dated January 3rd, 1903 These analyses are labelled top, intermediate and bottom respectively. An analysis of another sample of the rock from this quarry, by Mr. H. C. Mabee, is given in the table under Addington county.

Crystalline limestones from this county are described in the following terms:

(1) "is a dolomite [crystalline limestone] from lot 13 in the eighth concession of the Township of Madoc. "It is greyish-white in color, almost compact, with a conchoidal fracture, and a specific gravity of 2.849. This rock contains veins and disseminated grains of quartz.

(2) is a reddish granular dolomite from the village of Madoc, having a specific gravity of 2.834. Like the previous one, it contains quartz, and a little oxyd of iron, to which it owes its color. A portion of this, however, as in the last, is probably in the state of carbonate of protoxyd." (114)

(3) A fine-grained greyish-white magnesian limestone, lot 4 in the fifth concession of Madoc. (115). Specific gravity, 2.757.

	1.	2.	3.
Carbonate of lime....	46.47	57.37	51.90
" of magnesia	40.17	34.66	11.39
Peroxyd of iron ...	1.24	1.32	.....
Carbonate of iron...	.....	.....	4.71
Insoluble, quartz, etc	12.16	7.10	32.00
	100.04	100.45	100.00

"In the township of Madoc, on the thirteenth lot, and near the road between the seventh and eighth ranges, is a band of a fine-grained yellowish-white magnesian limestone, which would apparently yield a marble. Large blocks of a very good white marble have also been obtained from the adjoining townships of Elzivir and Marmora; that from the latter place is extremely pure, white, and compact." (116)

"Greyish limestones of this character are found in Tudor, where they sometimes form the wall rock of the veins of galena there met with. The limestones of that locality are, however, most commonly fine-grained and dark grey in color. Rocks of this character are met with all along the Hastings road in the south part of Tudor, also in lots 23, 24, and 25, range B, and on many other lots in that township. Quite as frequently however a part of the micaceous substance contained in them forms continuous sheets, imparting to the rock the character of a calc-schist. This grey, fine-grained limestone is perhaps more prevalent in Tudor than the more crystalline, granular variety to be noticed below, and is often met with in the township of Marmora, where a characteristic variety of it occurs on lot eight, range seven. It is also of frequent occurrence to the north of the village of Madoc, while to the south of it the limestone is more crystalline, and the micaceous layers are sometimes associated with iron pyrites. Similar varieties of this rock occur in the village of Bridgewater, one of them containing reddish calcspar and greenish mica.

"Granular limestone, sometimes purely white and saccharoidal, and at other times greyish, with a slightly banded structure, is plentifully met with in this region, and occupies a wide area in the eastern part of Hungerford. The town of Bridgewater stands upon another area of it, which has there furnished marble for building purposes.

"A little to the southeast of Madoc village it occurs white and crystalline, as well as grey and banded, and both varieties have been used as building stones. Other localities of this rock are Madoc, lots ten and twenty-four, range six; and Marmora, lot six, range eight, and lot sixteen, range eleven. A beautiful variety of dolomite occurs on lot twenty-seven, range one of Sheffield, and many of the micaceous limestones of this region are probably dolomitic." (117)

Marbles

The following notes on the marbles of Hastings county are taken from the Report of the Royal Commission on the Mineral Resources of Ontario, 1890. The first extract is from a statement by Mr. E. J. Whitney, pp. 80-82.

"My residence and home is at Gouverneur, in the state of New York. I am acting here as superintendent of the Hungerford Marble company's quarries. The capital of the company is $100,000. The marble at Gouverneur is very similar to the marble here, as is also the country rock, which is principally granite, gneiss and crystalline limestone. That marble sells well; in fact the demand is greater than the supply. The St. Lawrence Marble company have to run night and day to fill orders, and then cannot keep up. These crystalline marbles will stand the weather better than the metamorphic marbles of Vermont, and generally they work as easily. The quarries at Rutland, Vt., have dark stocks, and they always have orders in excess of their output, the dark being in great demand for outside work. The St. Lawrence company's marbles stand the weather better, polish as well and look as well. The Gouverneur quarries produce a blue stock that cannot be produced in the Rutland. There are a great many bands of that kind of marble here, and speaking generally all through the country there is any quantity of marble; all that is required is to go down far enough to where it is sound. Under similar circumstances on the other side of the line marble of satisfactory character is produced, and I am satisfied that as good can be found here, and that there is an enormous quantity of it; in fact I think there is no limit to the quantity. Very little of the Rutland marbles is used for outside work on buildings; it is not good for that purpose. The marbles here are good for either inside or outside work. Almost all colors are found, white, salmon, grey, black, mottled, drab, with black veins, with white veins, verde-antique and dove blue. All through St. Lawrence county, in New York, there are gravestones of crystalline marble that have been up 70 years, and they are perfect yet, though they were cut out of the surface rock. It will stand next best to granite, but will not moss like granite, and will stand fire better than any other stone. The old Fowler mansion, at Gouverneur, was built over fifty years ago out of just such stone; in 1874 it was burned down, and in 1875 some of the stone was taken to build an hotel. The only effect the fire had upon the stone was where it had gone out through the windows; there it crumbled the corners a little. In the academy at Gouverneur there is a slab that has been up since 1839, and it is as clean as when new. I had a marble shop burned down; the Italian marble all broke into little pieces, the granite also cracked to pieces, while the corners of the crystalline limestone just crumbled. There is no doubt that it makes the best building stone. Wherever marble takes a turn or bend it is never sound, but where it straightens out again it is good. I think the black marble here will turn out to be good, it is only a question of depth; in the Rutland quarries they did not get any that was good until they got to a depth of 100 feet. Good black marble is scarce, and if it is first-class it is worth as much as statuary; but as a general thing we cannot rely upon getting any quantity of it without being clouded. The demand is limited; the present price of a good fair article is $6 or $7 a foot sawed. The company has opend up two properties or quarries, one of them in the village of Madoc and the other about a mile and a half south of Bridgewater, on the Scootamatta river. The Madoc quarry was opened in the latter part of August, 1887. The band is about 900 feet wide from east to west; it curves, and I have traced it as far as Hog lake, a distance of about two miles from north to south. The lower wall on the east is granite; it dips about 10 degrees to the west. The upper wall is a mixture of granite and lime rock, but not what can be called a conglomerate. The dip is 10 degrees to the west. Beyond to the west is a slate which in some places is tipped up 30 or 40 degrees; in other places it is nearly horizontal. It would be good for roofing, but that it splits a little too thick. At present we have sunk on the Madoc property to the depth of 38 feet, but it is our intention to drill down 300 feet in order to get marble that will do for polishing. The marble is very good, the color a grey black. Its hardness is greater than that of the Vermont white marble, and about equal to the Italian marble. We find that the quality gets a good deal better as we go down. We have not as yet taken out any merchantable marble from that quarry, though we have taken out blocks part of which would be merchantable. At the quarry we have a 30-ton derrick, a diamond drill, a channelling machine, an Ingersoll gadder, a 35-horse power boiler, two steam pumps, and all the tools required; we have a full set of quarrying machinery. To run our machinery would take from eight to ten men, including one machine runner and two foremen; the rest would be quarrymen. The average wages here is $2.75 for machine runner, and $1.25 for quarrymen per day of ten hours; the wages are about the same as in New York State. Besides the Madoc quarry this company is working a white marble quarry near Bridgewater. The location there is about 40 acres in extent. The band is about 500 feet wide, and the course is about northwest and southeast. I have seen where it crops out a couple of miles above Bridgewater, but not below. It crops out at the surface, where work has been carried on. There are several small ridges, each of which shows white marble. The lower wall is granite; the upper wall is gneiss, and is very clearly defined. The marble is white, but has some cloudings of blue and green. The pitch is about ten degrees from the perpendicular to the west. There are two thin layers of salmon-colored stone, one about ten inches and the other eighteen inches. At the village of Bridgewater there is similar marble, and it was quarried twenty-five years ago to build a church and some private buildings. We worked our quarry there this summer, removed most of the surface material, and got down about 12 or 14 feet; the work was all done by hand. The quality of the marble is very good, and improves as we go down. A large amount of the surface stone taken out would only answer for building, but good merchantable marble is now exposed. We employed ten men there till about the 1st of August. We intend to test the property with a diamond drill. There is no property that I know of that could be so cheaply quarried as this one. It could be worked a good deal cheaper than the Madoc quarry. The marble would be suitable for monumental work; the low grade would make good trimmings for buildings, and the higher for interior and monumental purposes. The price at the mill would be $2 a cubic foot for the better, and down to fifty cents a foot for the poorer qualities. The shipping facilities are not good; we can only ship by hauling a distance of three and a half miles to Tweed (118). In a direct line, we are a mile and a-half from the railway. We were talking of putting up a marble mill, and running it by water power, and we could get a head of water of eight feet, but that has not been decided on as yet. The company has bought fifty acres from the Canada Company and ten acres from Mr. Clapp, a mile and a-half east of Bridgewater, on which there is a blue marble similar to that of Rutland. There is a g[illegible] of it from 50 to 100 feet w[illegible] distinct from the other. On th[illegible] Company lot there is a large [illegible] serpentine marble. I have ex[illegible] once, but have not done anyth[illegible] In serpentine, as a rule, there is a great deal of unsoundness, but this is fair; there is some white in it, and that makes it sounder. There are very few serpentine bands that I have seen as sound as this one. I do not know the width of the band, but judging from the outcroppings, I think it is from 300 to 600 feet wide."

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(114) G.S.C., 1863, 592-3.

(115) Ibid, p. 593.

(116) Ibid, pp. 822-3.

(117) G.S.C., 1866, p. 94.

Mr. J. E. Harrison gave evidence before the Commission on the Bridgewater marbles as follows:

"The white marble at Bridgewater is exceeding close-grained, rendering it very suitable for fine work, bearing sharp edges and undercutting. For building purposes it has few equals amongst the various kinds of stone now used, being capable of sustaining any pressure required for masonry, and being non-absorbent it is free from discoloration when exposed to the weather. This point of excellence is proved in the walls of buildings, erected from thirty to thirty-five years ago, which show no sign of becoming weathered. It has been used for over thirty years for making lime, and the lime business alone could be made very large and profitable, as has been proved by the experience of those engaged in it heretofore, notably that of the Dudswell Marble & Lime Co., of Sherbrooke, in the Province of Quebec. This firm ship, besides marble stone, an immense quantity of lime throughout the Province of Quebec and New England, reported by them to have been about 120 carloads per month for 1887. This lime, used for plastering, with clean sharp sand, is glossier, harder and whiter than a finish made of the best plaster of paris." (119)

Mr Alexander McLean's opinion as to the availability of Hastings county marbles was given as follows to the Commission:

". . . . Then, in one respect marble is very like dry goods, certain kinds are fashionable. Just at present the popular marble is the Tennessee; it is red, with white and variegated spots. There is no marble we produce that is at all like it. Those we have are principally crystalline limestone. I have seen some very fine marble in color and texture that came from back of Tweed, from a quarry that belongs, I think, to Mr. Sanford, of Hamilton. The color is white, and it is much less crystalline than the Bridgewater marble, but we cannot tell anything about that property till it is developed. I do not wish to be understood to say that crystalline marble would not compare favorably with other marbles for useful purposes. I think it will last better than any other marble, and I do not think it will stain as easily as the Italian marble. It would not take quite as good a finish as the best grades of Tennessee marble, but, of course, I have only seen what may be called surface specimens. . . . We have bought Tennessee marble ourselves in the open market. Fashion rules the demand, and there is not so much marble bought by one person that the duty would make any difference. The furniture dealers will not take marble that is not in the fashion; people will not buy an article that is unfashionable. It is impossible to force Canadian marble on the market. We have no opposition in granite from the

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(118) An extension of the Bay of Quinte railway was built past this quarry in 1903.

(119) Roy. Com., 1890, p. 82.

United States. There is any quantity of fine granite in the Muskoka and lake Superior districts. It is said that it has been used for bridges, and that it is free from checks and cracks. There is no object to go into granite the way prices are now unless we get special orders. We are not making any great effort to develop that trade; but the marble business is developing rapidly." (120)

The Commissioners state the results of their own observations in the following words:

"In the village of Madoc a band of crystalline limestone of the Laurentian series has been opened to a limited extent for the production of a dark-colored marble. The band is about 900 feet across, with a north and south course where opened, lying between granite on the east side and limestone on the west, beyond which latter again there occurs a band of slate or argillaceous shale. It is nearly vertical in position, pitching about 10 degrees to the west. The marble is a fair quality, crystalline and dark-colored, polishing almost black. Checks or joints occur here and there near the surface, but are said to become less frequent as the band is sunk upon. The quarry was nearly filled with water at the time of the commissioners' visit, so that a proper examination of it could not be made, but we were informed that a depth of 33 feet had been attained, and that at that depth the open floors were six to eight feet apart. There are various colored bands, chiefly grey (which, as above mentioned, polish almost black), grey and white mixed, and in other places some white in broader bands with the grey, which could be sawn out. This marble should be well adapted for all mourning purposes, as well as for designs where a dark-colored material is required. Its specific gravity is 2.782. The machinery on the ground consists of a 35-horse-power portable boiler, two steam pumps, an Ingersoll gadder, a diamond drill, a channel machine, a 30-ton derrick and necessary tools. Cutting is made with the drill, successive borings on the same line making a clean cut of any sized block that may be required.

"The Bridgewater marble quarry is in the township of Hungerford, in Hastings county, and is worked by the company owning the Madoc quarry. The strike of the band is north and south, dipping slightly eastward from the vertical. On the east is a quartzose rock, with large masses of quartz and feldspar, immediately followed by a close-grained pink-colored syenite. On the west side is a highly altered shale, dipping at a high angle. The latter varies in places from a gneissic to a chloritic, talcose and micaceous schist, succeeded by gneiss. This band of marble is some 500 feet wide, and curves around from north and south to south 30 degrees east. Where an opening has been made it is observed that the joints are at right angles to the strike and running with the dip, and are four to forty or fifty feet apart. The open floors are two feet to ten and twelve feet part. The seams vary from six inches to ten or twelve feet apart, the average being about two feet. The marble has a pure white color, clouded bluish and greenish in places, and with bands of pinkish or salmon color in other parts. These latter bands may be sawn out, being twelve to eighteen inches wide. The marble is closely crystalline, but compact, and is shown at Bridgewater to stand the weather well. A church has been built of it at that village, as well as portions of houses and stores, and they have stood over twenty years without showing any signs of weathering. It is said to be practically identical with the marble at Gouverneur, in the State of New York. The company expect to be able to ship large blocks, which pay best. The finest quality sells at $2 and the poorest at 50 cents per cubic foot. The specific gravity is 2.751." (121)

"The parti-colored limestone beds found in Seymour (at Allan's mills), and at the base of the Trenton outliers in Marmora, and in Madoc, yield a fine-grained grey marble thickly mottled with red and yellow colors" (122)

The following table shows the chemical composition of some of the Hastings marbles, or crystalline limestones; other analyses of representatives of this group of rocks are given on a preceding page:

CRYSTALLINE LIMESTONES

—	1	2	3	4
Insoluble residue	....	2.51	1.11	....
Silica	1.37	....	....	2.70
Ferric oxide	.82	.34	.56	1.71
Alumina			trace	1.64
Lime	50.10	53.64	47.49	48.28
Magnesia	3.88	.99	6.82	4.35
Sulphur trioxide	.10	.34	.18	.34
Carbon dioxide	43.32	42.92	43.91	42.60
Loss	....	....		
Alkalies	....	.25	....	....
Total	99.59	101.02	100.10	101.62

Sample 1 is from the marble quarry on the outskirts of the town of Madoc; 2 is from Ellis quarry on the Bay of Quinte railway, a short distance south of Actinolite (formerly Bridgewater); 3 represents a sample from Harrison's quarry, Actinolite, and is probably higher in magnesia than the average; 4. Limekiln quarry, York river, near Foster's rapids, township of Carlow.

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(120) Roy. Com., 1890, p. 236.

(121) Roy. Com., 1890, pp. 75-6.

(122) G.S.C., 1863, p. 827.

Marls

(1) "White lake deposit, lot 10, concession X, near Crookstown, Huntington township, Hastings county, 50 feet from G. T. R. and three-quarters of a mile from C. P. R. tracks. The deposit is 30 feet deep and there are clay deposits adjacent. The sample, which was taken from the bed of White lake, gave the following analysis: (123)

	Per cent.
$CaCO_3$	96.92
$MgCO_3$	0.31
Al_2O_3	0.18
Fe_2O_3	0.11
FeO	trace
SiO_2	0.98
Organic matter	not esti.
Sulphuric acid	trace
$CaSO_4$, $MgSO_4$	trace
Alkalis (K_2O) and Na_2O	not esti.
Total, estimated	98.50"

(2) "From a deposit at White Lake, lots eighteen and nineteen of the ninth concession of the township of Huntingdon. . . The marl extends out from the shore beneath the waters of the lake for variable distances—at some points, for one hundred feet or less; at others, for over two hundred feet or more. Little is known in regard to the thickness of the deposit, but this, in some places at least, has been found to exceed thirty feet

"The air-dried material is earthy, slightly coherent; colour, yellowish white. It contains but few shells and no visible root-fibres.

"It was found, by Mr. F. G. Wait, to have the following composition:

(After drying at 100 degrees C.—Hygroscopic water, 0.75 per cent.)

Lime	54.47
Magnesia	0.11
Alumina	0.06
Ferric oxide	0.08
Maganous oxide	traces
Potassa	traces
Soda	traces
Carbonic acid	42.87
Sulphuric acid	0.03
Phosphoric acid	0.01
Silica, soluble	0.08
Insoluble mineral matter	1.08
Organic matter, viz., vegetable fibre in a state of decay and products of its decay such as humus, humic acid, etc., and possibly a little combined water	1.84
	[illegible]

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 97.27 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of: (124)

Silica	0.82
Alumina and ferric oxide	0.21
Lime	0.03
Magnesia	traces
Alkalies	0.02
	1.08"

Huron

Extracts are given from Reports of the Geological Survey, descriptive of some of the limestones in the county of Huron, where the outcroppings are of comparatively small extent.

"Farther on, escarpments of twenty or thirty feet of the limestone [of the Corniferous formation] run through the west half of Carrick, and are said to extend southward into Howick." (125)

"Where the line between the townships of Ashfield and Colborne meets the lake, a little south of Port Albert, on the Ashfield or Nine-mile River, rocks come from beneath the high clay cliffs which face the water, and are seen at intervals along the shore for about a mile. The greatest section here exposed does not afford a vertical thickness of more than six feet. The rocks resemble a part of those at Point Douglas; they are destitute of fossils, and consist, in ascending order, of gray calcareous and bituminous sandstones, cherty limestones, brown calcareous beds striped with thin bituminous shales, and pale yellowish dolomitic layers, sometimes three feet thick; marked by lenticular crystals of calcite, or by cavities from which such crystals have disappeared. At the falls of the Ashfield River, about a quarter of a mile above Port Albert, there is exposed a series of thick-bedded grey calcareous sandstones, with buff colored silicious limestones, both holding organic remains, which are more numerous in the latter. . . These fossilliferous beds, like those of Point Douglas, probably overlie the unfossiliferous strata.

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(123) Cat. Ont. Min. Exhibit, Buffalo, p. 82

(124) G.S.C., 1894, p. 27 R.

(125) Ibid, 1863, p. 371.

"On the Maitland River, about four miles in a direct line from the shore of Lake Huron, there occurs on the first lot of the first range of Colborne, an exposure of yellowish-drab limestone. . . Beds similar to those seen on the coast and the river near Port Albert, and probably a continuation of them, occur in a cliff lower down on the Maitland, near Goderich. The following is a descending section of them :

"1. Dark grey thin bedded bituminous limestones, holding organic remains. . . 24 feet.

"2. Measures concealed by clay and debris, 12 feet.

"3. Pale grey or drab fine-grained sandstone, marked with ferruginous spots and stripes, and mottled with blue and yellowish colors; no fossils appear, 2 feet.

"4. Brownish calcspar, an aggregation of irregular crystals arranged in a bed, 1 inch.

"5. Dark brown, fine-grained sandstone, striped with bituminous layers; the rock is very soft and easily disintegrated, until after exposure to the air, when it becomes hard, 2 feet 6 inches. Total, 40 feet 7 inches.

"At the bridge across the Maitland River, about half a mile from the town of Goderich, and at a short distance below the place where the above section was measured, the following unfossiliferous beds are found exposed in a continuation of the same cliff. Four feet of dark grey bituminous and silicious limestone, followed by two feet of brecciated beds, are seen, which probably correspond to a portion of the measures, 2 concealed above. To these succeed :

"3. Pale yellowish calcareous sandstone, with ferruginous stripes and spots, 1 foot 10 inches.

"4. Brownish calcspar, an aggregation of irregular crystals arranged in a bed, 6 inches.

"5. Yellowish sandstone, with bituminous and ferruginous spots, 3 feet.

"6. Dark grey or brownish bituminous dolomite, with small lenticular crystals of calcspar ; some beds contain a large quantity of chert, and thin partings of bituminous shale, 4 feet. Total, 9 feet 4 inches.

"There is little doubt that the fossiliferous beds in all these various exposures, from Fort Douglas, belong to the Corniferous formation; while the lower non-fossiliferous strata bear a strong resemblance, in their mineral character and general aspect, to the Water-lime series. Their arrangement shows that we have here one of the minor undulations, to which allusion has been made." (126)

Analyses

"Limestone. This and the two following stones represent the material of three of the beds worked at a quarry on the eighth lot of the first concession of the township of Colborne, Huron county. . . .

"Stone from the fourth bed or layer, occurring at the quarry in question. Thickness of the band about 6 inches —more or less.

"An ashy-brown, very fine-crystalline, almost compact limestone.

"Its analysis afforded Mr. Wait the following results :

(After drying at 100 deg. C.—Hygroscopic water 0.06 per cent.)

Carbonate of lime		95.57
Carbonate of magnesia		2.77
Carbonate of iron		0.31
Carbonate of manganese		trace
Alumina	0.01	1.62
Silica, soluble	0.04	
Insoluble mineral matter	1.30	
Organic matter	0.27	
		100.27

"Stone from the thirteenth bed or layer of the quarry from which the preceding specimen was taken. Thickness of the band, about three inches—more or less.

"A yellowish-brown, fine crystalline, dolomitic limestone. An analysis by Mr. Wait showed it to have the following composition :

(After drying at 100 deg. C.—Hygroscopic water 0.04 per cent.)

Carbonate of lime		81.75
Carbonate of magnesia		15.06
Carbonate of iron		0.72
Carbonate of manganese		trace
Alumina	0.11	2.78
Silica, soluble	0.02	
Insoluble mineral matter	2.57	
Organic matter	0.08	
		100.31

"Stone from the twenty-fourth bed or layer of the quarry from which the two preceding specimens were taken. The thickness of the band, about six inches —more or less.

"A light yellowish-brown, fine to moderately coarse crystalline, somewhat magnesian limestone. Its composition was found, by Mr. Wait, to be as follows :

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(126) G.S.C., 18

(After drying at 100 deg. C.—Hygroscopic water 0.03 per cent.) (127)

Carbonate of lime		91.46
Carbonate of magnesia		6.22
Carbonate of iron		0.48
Carbonate of manganese		trace
Alumina	0.06	1.87
Silica, soluble	0.02	
Insoluble mineral matter	1.74	
Organic matter	0.05	
		100.03 "

Kent

The surface of Kent is similar to that of other counties which lie along the western half of the north shore of lake Erie, and is characterized by the presence of a thick deposit of drift. Wells have been drilled at a number of points, however, in search for oil and gas, which have given us a fairly accurate knowledge of the underground geology. Shale is usually struck immediately beneath the boulder clay. This is claimed to be in some cases part of the Portage formation; in others it is said to belong to the Hamilton. The following is held to represent a typical section near the centre of the township of Raleigh: (128)

	Feet.
Boulder clay, with occasional layers of sand and gravel	184
Shale, to	205
Limestone (argillaceous) to	211
Shale, to	240
Limestone, to	246
Shale, to	247
Limestone (middle lime, slightly argillaceous), to	249
Shale, to	278½
Limestone, very slightly argillaceous, becoming almost pure lime thereafter, to	511

" Another well was drilled, during recent years, about one mile northwest of the Grand Trunk Railway station at Chatham, which reached a depth of 1,000 feet, as follows: (129)

	Feet.
Surface clay	60
Shale, black [Portage]	118
Soapstone	200
Limestone	18
Soapstone	37
Limestone	567 "

Lambton

Exposures of limestone in the county of Lambton have been described in Reports of the Geological Survey and Bureau of Mines in the following terms:

"On the twenty-third, twenty-sixth and intermediate lots of the third range of Bosanquet, exposures of the rock [of the Hamilton formation] are met with, on the banks of a small tributary of the Riviere aux Sables (south). The following section in ascending order was measured on the twenty-fifth lot:

	Ft.	In.
Grey calcareous shale, imperfectly seen in a slope or talus on the stream	25	0
Grey calcareous shale, with. . . fossils	4	0
Grey solid limestone, composed of broken remains of encrinites	2	0
Grey soft shale, thinly laminated next the limestone, and filled with fossils. . . The upper part has the softness of clay	20	0
Grey decomposing shale, not well exposed	80	0
Grey encrinal limestone, weathering into small lenticular fragments, and holding bivalve shells, corals and encrinites	2	0
	133	0

"This section probably includes the strata of the neighboring exposures. . .

"At Jones's mill, on the third lot, upon the south boundary of Bosanquet, on the bank of another small tributary of the Riviere aux Sables (south), the following ascending section is exposed:

	Ft.	In.
Brownish grey-weathering shales	25	0
Grey encrinal limestone	2	0
Grey decomposing shale	3	0
	30	0

". . . . At Austin's mill, on the fourth lot of the first range of the same township, on another small stream, there is a corresponding section, where the grey encrinal limestone which forms the uppermost layer of the exposed strata, is five feet thick. Below this band, the strata are characterized, as before, by a great abundance of Spirifera mucronata; and in the bed of the stream, at a level probably fifty or sixty feet below the encrinal limestone, there is a band of solid arenaceous limestone, about 7 inches thick." (130)

The other formation, exposures of which occur in this county, is known as the Portage-Chemung. It is composed essentially of shales, which are often highly bituminous.

Logs of the numerous wells which have been sunk in search of petroleum

(127) G.S.C., 1899, pp. 33-34 R.

(128) B.M. Vol. XII., p. 41.

(129) G.S.C., 1890-91, p. 73 Q.

(130) G.S.C., 1863, pp. 382-5

show the character and arrangement of the strata which underlie various parts of the county.

"The heavy deposits of drift continue westward from St. Mary's, being represented by rolling boulder clay, interrupted in places by deposits of sand. After passing Lucan, some moraine hills are encountered, which however soon give place to remarkably level clay land. No rock exposures are seen over the entire region until the famous Hamilton outcrops at Thedford are reached. The excellent series of rocks rendered accessible at this point have become classic in the annals of geology, as they form an exceedingly rich hunting ground for the fossils characteristic of the Hamilton formation. So much has been published on the fauna of these rocks that it would be superfluous for the writer to deal with that side of the matter here. An idea of the richness of the remains may be gathered from the fact that, in spite of time spent in travelling, he succeeded in three days in collecting over a thousand specimens, representing 110 species. Some attempt was made by the writer to work out the fossil contents or at least to establish the characteristic fossils of the various layers, but he is glad to find that this had been done by others in greater detail than his time would permit. Professor A. A. Wright during the summer of 1900 made a complete series of measurements, and during the season of 1901, Professors Shimer and Grabau made exhaustive collections. The results of their work are published in a valuable bulletin of the Geological Society of America.

"It may be well however to describe briefly the places at which exposures are to be seen. The first is at Thedford, where the Grand Trunk railway cuts through the series to a depth of forty feet. At this point Spirifer pennata (Spirifer mucronata var. Thedfordensis of the above authors) is very abundant, as well as bryozoa of different genera. This section is also much the best for the collection of Athyris spiriferoides, Goniatites uniangularis and Cyrtina Hamiltonensis. Shimer and Grabau mention 39 species from here, mostly bryozoa and brachiopods. A second exposure is found three-quarters of a mile north of the railway cut in what are known as Hanniford's fields. A heavy limestone with crinoid stems is here overlaid by a soft shale from which weather out numerous specimens of corals which may be picked up in perfect condition on the surface of the ground.

"Besides the corals fourteen or fifteen species of brachiopoda occur.

"Fragments of bryozoa and joints of crinoids are also abundant.

"The third section is found on a small stream west of the above and presents practically the same series of rocks, reaching however a greater vertical extent. The top is decomposed coral shale underlaid by limestone in several layers, beneath which is fifteen feet of blue clay. This material makes excellent drain pipes and brick of a red color, while the overlying boulder clay burns white. The blue Hamilton shale is filled with nodules of a harder nature which prove objectionable on account of their resistance to the action of both fire and water. An analysis of one of these nodules follows:

	Per cent.
Water...	0.57
Silica...	17.67
Alumina...	10.59
Ferric oxide...	4.23
Calcium oxide...	32.[illegible]
Magnesium oxide...	traces

"The nodules would seem to owe their origin therefore to concretions of lime which has entered into chemical union with the elements of the shale. The assemblage of fossils is, as would be expected, about the same as in Hanniford's fields and the railway cut.

"Probably the best section of these Hamilton rocks is to be seen in Rock Glen, where a small tributary of Aux Sables river has exposed 70 feet of the series. Another excellent section of the lower portion is seen at Marshall's Mills on the Aux Sables, about a mile above the mouth of Rock Glen. Finally small exposures are met with in the valleys of creeks cutting down to the rock on the road from Thedford to Arkona. Particularly may be mentioned a good section at 'No. 4 hill.' At Stony Point, lake Huron, the heavy limestone is exposed for a short distance along the shore. . . .

"An analysis of this limestone is given below, as well as one of what is probably the same bed from Thedford:

	Stoney Pt., per cent.	Thedford, per cent.
Water...	0.14	.....
Silica...	0.78	1.51
Alumina..	0.13	2.19
Ferric oxide.. ..	1.56	2.49
Calcium oxide	51.74	51.26
Magnesium oxide . .	0.46	traces.
Sulphur trioxide ...	1.27	.....
Carbonic acid and loss...	43.02	41.10

"It will be observed that this stone is practically free from magnesia, although the sulphur may prove objectionable for certain chemical purposes.

"Below are shown side by side sections of the Hamilton formation at Thedford as prepared by Professor Wright and by Professors Shimer and Grabau. My observations, made a year later, can add nothing to the systematic measurements

Bed No.	Shimer and Grabau.	Feet.
9	Calcareous Ceratopora Bryozoa beds	10
8	Shales with Spirifer beds at base	8
7	Argillaceous limestone	1.5
6	Blue calcareous shale	18
5	Calcareous shale and slaty blue limestone	6
4	Argillaceous shales with Styliolila.	1.5
3	Coral layers	8.25
2	Encrinal limestone	3
1	Blue shales, lower, with calcareous fossil beds	30
	Total	81.25

A. A. Wright.	Railway cut and Hanniford's fields.	Rock Glen.	No. 4 Hill.	Marshall's Mills.
	Feet.	Feet.	Feet.	Feet.
Encrinal limestone	2	4	6	......
Nodular shale	1	6.6	4.1	......
Upper argillaceous limestone.	14	2	1.6	......
Upper blue shale.	37.6	37.9	29	......
Lower argillaceous limestone	1.3	1.3	1.3	1.3
Coral beds	......	3.9	3.9	3.9
Rugosa limestone	......	2.6	2.6	2.6
Lower blue shales	......	20	20	20
Calcareous blue shales	......	15	15	15
Total	84 feet.			

of these geologists. For detailed information as to the fossil content of the various layers the reader is referred to the publication already cited.

"The various shales, particularly those free from fossils, make excellent tile and coarse pottery. Mr. Jas. Cornell has for years carried on this industry at the exposure on the creek north of Thedford. Rock Glen and Marshall's Mills both furnish equally good sites for this purpose. The limestones are practically free from magnesia and alumina, making splendid lime and the even-bedded portions are easily quarried for building stone. Two miles north of Thedford a gravel ridge is crossed, beyond which a distinct beach is seen (Algonquin beach), representing the shore line of lake Huron in post-glacial times." (131)

Lanark

Crystalline limestone suitable for several purposes is found at many points in this county. At Carleton Place one of the chief lime producers in the eastern part of the Province uses this rock. In other localities the stone is quarried for use as a building material, some of it being adapted to decorative purposes.

Cambrian and Silurian limestones—Calciferous, Chazy and the Trenton group—are also found, especially in the more northeastern and southeastern parts of the county, where they form somewhat irregularly-shaped areas overlying the crystalline series of the Laurentian. The strata of these formations here are similar in chemical composition and other characteristics to the corresponding ones in the adjoining counties, Carleton and Grenville.

Exposures of the Calciferous formation are found in the townships of Pakenham, Ramsay and Beckwith.

Limestones of the Chazy formation are exposed in Ramsay and adjoining townships; those of the Trenton group outcrop in Pakenham and Ramsay.

"On the Rideau canal it [the Calciferous formation] is seen at Smith's Falls, in a cliff of thirty feet." (132)

Following are analyses of certain crystalline limestones found in this county:

—	1	2	3	4
Insoluble residue.	1.32	1.12	3.06	1.20
Silica	....	....	....	......
Ferric oxide	.49	.38	.46	.49
Alumina				.97
Lime	50.80	51.20	49.86	43.82
Magnesia	3.33	2.28	3.36	9.19
Carbon dioxide	43.51	44.50	42.69	44.00
Water	....	.08	....	......
Loss	....	....	.31	......
Sulphur trioxide	.06	.32	.28	.46
Alkalies	....	....	....	......
Total	99.51	99.88	100.02	100.13

1, Stone used at Cameron's lime kiln, Carleton Place; 2, dark crystalline limestone, Lanark village; 3, lighter colored stone at the same place; 4, lot 2 in the fourth concession of North Burgess.

"Mr. Hoffman has examined both the bluish-grey and white layers of a specimen of this limestone, from the twenty-first lot of the tenth range of Lanark. The former contained finely disseminated graphite (the cause of their color), and likewise a considerable quantity of tremolite in crystals, some of which were more than half an inch in length. The white layers, however, were free from graphite, but contained a little tremolite in microscopic crystals. Minute grains of glassy quartz were also found in both the grey and white layers. The material for the following analyses was freed as carefully as possible from impurities, and dried at 100 degrees C.:

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(131) B.M., Vol. XII pp. 153-156.

(132) G.S.C., 1863, p. 118.

	Grey layer.	White layer.
Carbonate of lime	77.39	90.38
Carbonate of magnesia ..	20.57	8.32
Carbonate of iron	.78	.51
Graphite	.16	.....
Insoluble	1.26	.90
	100.16	100.11

"A specimen of this dolomite [brown-weathering, crystalline, magnesian lime stone, abounding in tremolite], from the twenty-second lot of the eighth range of Lanark, has been analysed by Mr. Hoffman. It was separated as far as possible from tremolite, and after drying at 100 degrees C. gave : (133)

	Per cent.
Carbonate of lime	52.12
Carbonate of magnesia.. .. .	42.10
Carbonate of iron......	.80
Insoluble	5.78
	100.80 "

Quarries

"Limestone.—From lot twenty-four, range nine, of the township of Ramsay. . . . The quarry from which this stone was taken is situated close to the Indian River, where a great thickness of this limestone occurs. Geological position—Laurentian.

"Structure, somewhat coarsely crystalline ; color, faintly bluish-greyish-white. It contains, here and there, a minute grain of pale yellow chondrodite, and numerous small scales of graphite.

"It was found—by Mr. R. A. A. Johnston—to have the following composition :

(After drying at 100 degrees C.—Hygroscopic water 0.07 per cent.)

Carbonate of lime		91.63
Carbonate of magnesia		6.61
Carbonate of iron.		0.41
Alumina	0.14	
Silica, soluble	0.05	
Insoluble matter	1.13	
		1.32
		99.97

"This stone has been extensively quarried for the manufacture of lime, and small quantities have been employed in Pakenham and Almonte for foundations and facings of buildings.

"Limestone.—Occurs on lots nine and ten of the sixth range of the township of Ramsay. . . . The same stone also occurs on lots nine and ten of the fourth and fifth ranges, and on lot sixteen of the second range, and many other places in this township. Geological position—Laurentian.

"Structure, coarsely crystalline; color, white, but not pure white. It contains an occasional grain of pale yellow chondrodite, and here and there a scale of graphite.

"Agreeably with the results of an analysis—conducted by Mr. R. A. A. Johnston—it contained :

(After drying at 100 degrees C.—Hygroscopic water - 0.09 per cent.)

Carbonate of lime....		90.05
Carbonate of magnesia..		6.51
Carbonate of iron..		0.42
Alumina		
Silica, soluble..	0.06	
Insoluble matter	3.26	
		3.32
		100.30

"This stone has been extensively used for the manufacture of lime." (134)

Marl

"From a deposit on the thirteenth lot of the fourth concession of the township of Lavant. . . . The deposit covers an area of rather more than six acres, and is over seven feet deep.

"The air-dried material is earthy, slightly coherent; color, yellowish-white. It contains but few shells or root-fibres.

"Its composition was found, by Mr. F. G. Wait, to be as follows :

Lime	53.17
Magnesia	0.06
Alumina	0.10
Ferric oxide	0.08
Manganous oxide	0.02
Soda	0.10
Carbonic acid	42.02
Sulphuric acid	traces
Phosphoric acid....	0.01
Silica, soluble	0.02
Insoluble mineral matter	0.24
Organic matter viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	3.66
	99.48

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(133) G. S.C., 1874-75, p. 141.

(134) G.S.C., 1888-89, pp. 24-25 R.

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 94.95 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of: (135)

Silica	0.15
Alumina and ferric oxide	0.07
Lime	0.01
Magnesia	traces
Alkalies (?)	0.01
	0.24"

Lime Kilns

Mr. W. M. Cameron operates lime kilns in the town of Carleton Place. The rock burned, which is crystalline limestone, is quarried in the fifth concession of the township of Ramsay, and teamed to the kilns in winter. An analysis of a sample of this rock is given in the preceding table. The kilns are of the continuous draw-kiln type, and have a capacity of 150 bushels in 24 hours. The fuel used is wood. The lime is white and slakes readily. There is no "combine" among lime manufacturers in eastern Ontario. Lime sells for 20 cents a bushel f.o.b. Carleton Place. Competition was met in former years at Brockville with lime from as far west as Beachville. Carleton Place lime is shipped as far east as Cornwall. It meets with competition from Renfrew lime at Ottawa and Arnprior. Mr. Cameron has furnished the paper mill at Cornwall with lime, which is said to give excellent satisfaction. A sample barrel has been sent to the Eddy mills at Hull, the lime for which has been heretofore imported from Swanton, Vermont state. Mr. Cameron is a member of the firm of Cameron Bros., who manufacture lime from crystalline limestone in the village of Delta in the county of Leeds. The plant at this place is similar to that at Carleton.

A mason told the writer that "the white crystalline limestone near Lanark village and through the township of Ramsay, makes good lime. It is 'cooler' than that of Renfrew. The lime from the vicinity of Ottawa city is quick setting. By using it one can 'spread' 4 or 5 bricks, while with Renfrew lime the number is 10 or 12."

Leeds

Outcrops of crystalline limestones are found at numerous places in this county. These rocks ". . . are extensively exposed in Bastard and South Crosby; their color is usually white, but sometimes greenish-white, or white with grey bars or stripes. Small scales of graphite are invariably disseminated through the rock, with serpentine, mica, and iron pyrites, and in the twenty-seventh lot of the third range of South Crosby chondrodite is of frequent occurrence, the disseminated mineral alternating with bands containing mica. On the twenty-fourth lot of the tenth range of Bastard a bed of conglomerate is interstratified between two of the beds of limestone." (136)

The use of crystalline limestone at Delta in the production of lime is mentioned under Lanark county.

The Calciferous formation is seen at many points. "In Young [Yonge] it is exposed on the eleventh lot of the eighth and ninth ranges, at Loyada Lake, in the rear of the township, and also in Kitley, near the village of Kitley Corner. . . The stone has been used for building purposes at Brockville and Prescott, and in the neighborhood of Brockville and Mirickville; some of which yields good lime of a dark color, producing a mortar of considerable strength." (137)

Quarries

The writer visited a number of limestone quarries in the vicinity of Brockville. Sherwood's quarry is situated a short distance northeast of the Insane Asylum. It has a face six feet in height, with thin covering of soil. The beds average about six inches in thickness. The color of the rock is dark grey or brownish. Dyer's quarry adjoins that just mentioned. It contains one bed 14 inches in thickness. Some of the stone is used in the manufacture of window sills, five or six inches in thickness. There is a quarry on the Asylum property, on lower ground than Sherwood's or Dyer's, but similar in character. This quarry lies not far from the roadside, between the Asylum buildings and the Grand Trunk railway. Rock outcrops at Murphy's Corners, where there is a good site for a quarry. Easton's quarry is about two miles northwest of Brockville on the Perth road. It contains thick-bedded, dark grey limestone. One bed has a thickness of eighteen inches. The rock contains geodes of calcite.

Following are the results of analyses of samples of the rock taken by the writer from the Brockville quarries:

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(135) G.S.C., 1894, pp. 24-25 R.

(136) G.S.C., 1863, p. 31.

(137) Ibid, p. 118.

—	1.	2.	3.	4.	5.	6.
Insoluble residue	....	....	....	....	19.52	....
Silica	4.80	8.76	7.00	3.68	....	6.28
Ferric oxide	1.00	.99	.57	1.22	1.01	.81
Alumina	3.32	3.84	.79	.80	.81	1.06
Lime	30.10	28.31	29.20	30.94	25.92	35.00
Magnesia	15.49	15.39	17.96	17.46	15.36	12.26
Carbon dioxide	40.63	39.00	43.75	43.20	37.20	40.93
Water	....	....	.88	....	....	....
Loss on ignition	3.97	1.35	....	....	.22	....
Sulphur trioxide	.75	.47	.41	.46	.86	.62
Alkalies	.85	.90	....	....	....	....
	100.91	99.01	100.56	97.86	100.90	96.95

1. Dyer's back quarry; 2. Asylum quarry; 3. Dyer and Sherwood's quarry; 4. A more carefully selected sample than 3, from the same quarry; 5. Murphy's quarry; 6. Easton's quarry.

Marl

"In the township of Yonge, on the thirteenth lot of the eighteenth range a bed of marl occurs beneath a marsh, and is said to extend over twenty or twenty-five acres. Its thickness was found to be seven feet, but it is reported to be fifteen feet in some parts of the deposit. Marl has also been found in the bays on the south shore of a lake in Elmsley, where it has a thickness of three or four feet, and extends beneath the water of the lake." (138)

Lennox and Addington

(See under Addington).

Lincoln

The escarpment of the Niagara formation crosses the river from New York State, and enters the Province in the township of Niagara. The 'heights' in this township are well known from their historical connections.

The sandstones, Potsdam, which underlie the Clinton formation are exposed at the mouth of the Niagara river, and in many other places in the county.

"In Canada, for reasons which will be stated in describing the Niagara formation, it is found convenient to limit the Clinton to the strata beneath the Pentamerus band, and to include this band in the Niagara formation. On the Niagara River the Clinton is thus limited to a few feet, but it gradually augments in thickness to the northward." (139)

"Crystals of the latter mineral [galena] exist in greater or less quantity in nearly all the limestones from the Pentamerus band to the summit of the upper beds [of the Niagara formation]; but they are in the greatest abundance in the latter, especially in the township of Clinton, near the village of Beamsville, where an unsuccessful attempt was made by Mr. Lee to establish a lead mine upon what was supposed to be a lode, on a lot of the eighth range of the township. . . . . The supposed lode, however, appears to be rather one of the open joints or fissures, running east and west, by which these rocks are intersected in many places. In the locality in question, the fissure, which is filled up with drift, is crossed by small cracks, the walls of which are invested with crystals of pearl-spar and galena. The ore is also seen on each side of the main fissure, and is moreover disseminated throughout the limestone, near the fissure." (140)

Queenston Quarries

"The Queenston quarries are located on lot 48 on the Queenston and Grimsby stone road, in the township of Niagara, two miles west of the village of Queenston. The lot is the property of William M. Hendershot, of Thorold, and the quarries are worked by P. A. Johnston & Co., who have held them under lease since 1881. Previous to that time they had been worked for three years by Hunter, Murray & Cleveland, who had the contract for building the Welland canal aqueduct at the town of Welland; while for the preceding four years, beginning with the spring of 1874, they had been worked by Belden, Denison & Co., who had contracts for the construction of locks on the new canal. It is said that the quarries were first opened during the construction of the Grand Trunk railway.

Seven quarries have been opened on the property, all of which are in the limestone beds of the Niagara formation.

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(138) G.S.C., 1863, p. 765.

(139) Ibid, p. 312.

(140) G.S.C., 1863, pp. 324-5.

"The several beds differ essentially in color and texture—from light grey to blue, and from soft and porous to dense and crystalline.

"After stripping from two to ten feet of clay a grey limestone bed is reached, whose surface has been deeply grooved by glacial action. It is a fossiliferous rock, consisting of lime and sand, and is used in the production of lime, and for culvert and bridge works on railways.

"Below the gray is a bed of blue limestone of ten to twelve feet in thickness, composed in some of the quarries of two bands, the upper of which is a light and the lower a dark grayish blue; in others it is composed of the dark blue only. Both are crystalline, but while the upper is coarse grained the lower is fine-grained, approaching marble, and is much superior in quality to the other. This bed contains a large variety of fossil shells, is hard and durable, tools well, and takes a fair polish. The stone taken from it is used almost wholly for the bases and shafts of monuments, for which a large business has been built up. But it is used also for building purposes, the post offices at Cornwall, Niagara Falls and St. Catharines having been constructed with it besides many private dwellings and business houses.

"Below the blue limestone is a bed of dark limestone, which has a proportion of clay in its composition, is from four to six feet in thickness, and suitable for the manufacture of cement.

"Johnston & Co. employ an average of 75 men at their quarries." (141)

Gibson's Quarries

"These are the property of Mr. William Gibson, M.P., and are situated on the top of the mountain a mile and a half south of the village of Beamsville, in the township of Clinton, and two and a half mile from Beamsville station on the Grand Trunk railway. The property embraces an area of 45 acres, and the limestone rock where not exposed is covered with only a few inches of soil.

"The quarries were opened by Mr. Gibson in May, 1884, and have been worked continuously since with a large force of laborers, quarrymen and stonecutters. The amount paid for wages in 1890 was $87,440, but last year the staff of workmen was increased, and in the month of June 160 were employed; the wages paid to quarrymen alone in that month being $7,500.

"There are two workable beds of gray limestone, the upper being seven and the lower eight feet in thickness. The upper is usually the best quality, being firm, hard and crystalline; but both contain many fossils, and have openings or vughs which are lined with crystals of iron pyrites. In some parts of the quarries the beds are three in number, but the lowest is not more than two or three feet in thickness. Below these workable beds is a bed of porous gray limestone, but it is rarely of a quality fit for use.

"Three large derricks are worked by as many engines, one of which is 24 and the other two of 18 h.p. each, the more powerful one driving a steam drill in addition. Three other derricks are driven by horse-power. A fourth boiler of 35 h.p. drives three steam drills. Three small drills are used for plug and feather work.

"The stone is all cut by hand, and is used largely for the construction of bridges, culverts, tunnels and buildings on the lines of the Grand Trunk railway. The tunnel under the St. Clair river was built by Mr. Gibson with stone taken from these quarries.

"The quarries are about 200 feet above the level of the station, down to which the stone is carried in cars over a tram road built along the side of the public highway. It could be conveyed the whole distance by gravitation, but to prevent accidents the cars are stopped before they reach the main street of the village. From that point they are taken by horses to the station and empty ones are drawn back to the quarries.

Grimsby Quarries

"The Grimsby quarries are in the gorge of Forty-Mile creek, above the village of Grimsby, which cut through the limestone into the Medina sandstone and extends back through the mountain to the falls on the creek, a distance of half a mile. The quarries are the property of the Grimsby Quarry Co., of which Stephen Webster, of Toronto, is president and Frank Webster manager. The location is about half a mile in length, extending from the edge of the escarpment on either side of the gorge to near the Falls, and occupying an area of 18 acres.

"The bottom and sides of the gorge are covered with a talus of limestone and sandstone, and these stones are being removed preparatory to opening the sandstone in place. A tram-road has been built to the docks at the lake shore, a distance of one mile and a half, down which the cars are run by gravitation, and up which they are drawn empty by horses, as at the Gibson quarries at Beamsville.

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(141) B.M. Vol. I, pp. 95-96.

"The mountain here is about 350 feet above the lake, and about 100 feet of the top consists of limestone and shale. Underneath the shale are bands of gray, brown and mottled sandstone, alternated with bands of shale. At one place, where it is well exposed the brown band, slightly mottled, is about 15 feet in thickness, of good texture, solid and capable of being cut into any suitable size for building purposes.

"The company was organized in 1890 with a capital of $20,000, 75 per cent. of which was paid up, but although work was commenced in November of that year, no stone was taken out until the spring of 1891.

"Stone is being supplied for the cribwork at the eastern and western gaps of Toronto harbor, but no dimension stone has yet been taken out. The company employs from thirty to forty men." (142)

"Grimsby, Ontario—In the Niagara formation at Grimsby there are beds of dolomite, one to three feet thick, from which stone has been obtained for building purposes. The rock is crystalline, brownish-gray in color, and holds a few fossils. Some of it when dressed with a plain surface has a pitted appearance. Analysis of a specimen gave : (143)

Carbonate of lime	68.92
Carbonate of magnesia	29.48
Corbonate of iron	1.10
Insoluble matter	0.50
	100.00"

Manitoulin Island

The Manitoulin, or as it is sometimes called the Grand Manitoulin, island and a number of the islands to the north and west of it in Georgian bay are underlaid by unaltered rocks of the Silurian (Cambro-Silurian and Upper Silurian) system. These rocks outcrop as bands, running across the Grand Manitoulin, from east to west, in the direction of its greatest diameter. These formations range in age from the Chazy, which has not been proved to be present with certainty, or Black River, to the top of the Niagara. It is considered doubtful whether certain beds on the south should be classed as Guelph or should be grouped with the Niagara. From the lower part of the Trenton group to the upper part of the Niagara all the formations recognized in the more southern part of the Province are present with the exception of the Medina, and they possess the characteristics of the outcrops to the north of lake Ontario and to the westward. The Niagara, e.g., here forms an escarpment similar to that occupied by this formation from the Niagara river to the Georgian bay.

These formations on the island—Trenton, Utica, Hudson River, Clinton, Niagara and Guelph (?)—present a section from north to south across the island which is unsurpassed anywhere for the purpose of study and comparison. Rocks of all these formations can be visited in a few hours. At Little Current, for example, at the water's edge and for some feet above, we have exposures of the Trenton limestone. This is capped at the top of the hill a short distance from the shore by Utica shales. The higher hills to the southward, which can be seen from the village, are underlaid by the Hudson River formation. Farther south again we meet with the Clinton and Niagara limestones.

The late Alex. Murray, Dr. Robert Bell and other officers of the Geological Survey have described the geology of the Grand Manitoulin and adjacent islands. The reader is referred to the reports by these gentlemen for details concerning the distribution of the different limestone bearing formations. (144)

The following table gives the results of analyses made by Mr. A. G. Burrows of samples of limestone collected on Manitoulin island by the writer last summer:

	1	2	3	4	5	6	7	8	9	10	11	12	13
Insoluble matter ..					.....	[illegible]		[illegible]	[illegible]				
Silica	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	[illegible]	..		[illegible]	[illegible]	[illegible]	1.42
Ferric oxide	[illegible]	.71	[illegible]	[illegible]	[illegible]	.72	[illegible]	[illegible]	[illegible]	1.72	[illegible]	.88	[illegible]
Alumina	trace	[illegible]	[illegible]	1.80	[illegible]	.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..
Lime	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Magnesia...........	[illegible]	[illegible]	[illegible]	[illegible]	19.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Carbon dioxide.......	[illegible]	[illegible]	47.40	[illegible]	[illegible]	45.27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47.00
Water					......	..		[illegible]					
Loss	[illegible]			...	.16	[illegible]	.25	...		[illegible]		[illegible]	....
Sulphur trioxide ..	[illegible]		[illegible]	...	.30	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	......
Alkalies	[illegible]		[illegible]	......		[illegible]						[illegible]	
Total	100.67	99.97	100.90	99.47	99.98	100.65	98.56	99.45	98.57	99.95	99.68	99.81	99.93

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(142) B.M., Vol. I., p. 97

(143) G.S.C., 1876-77, pp. 486-87.

(144) Reports for 1863, pp. 63, 194-6 216, 19, 320, 332-34 ;1863-6, pp. 165-179 ; 1866-9, pp. 169-177. 449-460; 1896, pp. 1 to 29 I.

Following are the localities from which the samples represented by the above analyses were taken: 1 and 3, Ryan & Haney's quarry, a few miles from Meldrum Bay P. O.; 2. Top of hill at Meldrum Bay village; 4, Gore Bay, sample of 12 feet of the uppermost part of the face of the cliff, northwest of the Fair grounds; 5. Top of the cliff across the bay, east of the village of Gore Bay; 6. Gore Bay, one-quarter mile west of the northwest corner of the Fair grounds, cliff 6 feet; 7. Porter's quarry, just east of the Fair grounds, Gore Bay; 8. Talus along face of cliff on the east side of Gore bay; 9. Kagawong, uppermost three feet near top of cliff, along road; 10. Little Current, four feet top of cliff, west of the village; 11. Landing at lake Manitou; 12. Upper four feet of cliff at Manitowaning; 13. Fossil hill, near Manitowaning, sample from layer under fossiliferous zone.

Concerning the thickness of the several formations, which are quite undisturbed and dip slightly to the southward, the rate being estimated at about 40 feet to the mile, Dr. Robert Bell says:

"A vertical section from the mainland along the western border of the sheet, somewhat produced to the south, would show the following thickness for each of the successive formations from the base upward: (145)

	Feet.
Chocolate marls and fine sandstones (Chazy?)	100
Trenton group [Black River, etc.].	320
Utica formation...	60
Hudson River formation....	250
Clinton formation.....	177
Niagara formation....	405
Guelph formation (?)...	100
Total thickness...	1,412."

These limestones of the Trenton group and the Clinton and Niagara formations in many localities when burned produce lime of good quality. The strata in many places are also suitable for the production of stone for building and other structural purposes. The Clinton and Niagara, which afford the layers of the most uniform composition and the most easily worked, are, like those of the same formation in the more southern part of the Province, magnesian, and thus are not suitable for use in chemical and metallurgical industries requiring a lime comparatively free from magnesia. Rock high in magnesia is required in some industries, e.g., in the manufacture of sulphite pulp, and rock from a quarry on Cockburn island has been used for this purpose in the mills at Sault Ste. Marie. Limestone carrying magnesia, if the percentage of this material is not too high, can be used as flux in blast furnaces and in other industries.

"The Silurian rocks of Manitoulin and Fitzwilliam islands afford a variety of good stones for ordinary building purposes, and some kinds suitable for heavy structures. The latter may be looked for among the thickly-bedded buff-colored dolomites of the Clinton formation and the gray dolomites of the upper part of the Niagara. The Guelph formation, which appears to be represented by the highest rocks in the southern parts of these islands, is heavy-bedded and would yield stone of large dimensions, but of a porous character. . . .

"Shell Marl.—This substance is found under a few of the limited peaty swamps and marshes, and also under some of the smaller lakes or their dried-up sites on Manitoulin island. Where the soil already contains so much carbonate of lime as does that on this island, these marls will not be required as fertilizers, but they may prove useful in the manufacture of hydraulic cement. . . . .

"Lime.—The limestones of Manitoulin island appear to be all dolomitic, except those of the Trenton group and some of the beds in the Hudson River formation. Both the dolomites and the pure limestones have been calcined for use by the farmers in the various parts of the island, where they occur, and have been found to yield excellent lime." (146)

"The greater part of La Cloche Island and of the other principal islands between the north shore of Lake Huron and the Manitoulin Island, consist of dolomites and thin-bedded light grey and somewhat argillaceous limestones of the Trenton group. The upper portion of this group, of a somewhat more massive character, occurs on Manitoulin, forming the northern part of the peninsula between Wequemakong and Manitowaning Bays, and skirting the northern extremity of the island for six miles from Little Current to West Bay. In the former area there may be about 80, and in the latter 40 feet of strata belonging to this group, counting from the lowest bed, which comes to the level of lake Huron." (147)

Hudson River Formation

The Hudson River formation on the island consists of soft marly bluish-drab colored shales, interstratified with limestone. At Cape Smyth, on the eastern end of the island, this formation has a thickness of about 300 feet.

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(145) G.S.C., 1896, p. 25 I.

(146) G.S.C., 1896, p. 27 I.

(147) Ibid, 1863-66, pp. 170-1.

"To the south of Sheguiandah Bay, and of Little Current the thickness appears to be about 250 feet, and at Maple Point 220 fet. About 145 feet are exposed on Barrie Island, and 137 at Cape Robert. . . . .

"The following is a descending section of the cliff on the west side of Cape Robert:

Brown-weathering, drab and bluish-grey argillo-arenaceous limestone—mostly thin-bedded, or when thicker, breaking away in irregular lumps. This band forms the perpendicular and overhanging portion of the cliff, and is here and elsewhere on the island, characterized by a large concentric coral....	17
Crumbling calcareo-arenaceous shales of a bluish-drab color..	10
Hard grey calcareous beds, interstratified with bluish-grey shale....	3
Bluish-grey clayey shale.....	25
Hard grey calcareous bed .	2
Bluish-grey arenaceous [illegible] bling marl....	30
	87 feet (148)

"The edge of the plate[illegible] the Hudson River f[illegible] [illegible] self in a high bluff all along [illegible] side of Grand Manitoulin from Maple Point to Julia Bay. Gore Bay, [illegible] interval, lies in a deep notch cut out of the plateau. The strata are finely exposed in the bold escarpments on either side of this bay. The southward dip, at the rate of about one in fifty, is here quite perceptible. Local slides and debris obscure the outcropping edges of the beds in some places, and the following section, from the water's edge upwards, was not obtained in one straight line, but by connecting two exposures lying close to one another, and is presumed to be almost as correct as if measured continuously. It was obtained on the east side at the entrance to the bay, commencing at the level of Lake Huron.

"1. Bluish and drab-grey argillaceous and finely arenaceous shale—bands of darker and lighter shades alternating—crumbling and wasting away easily under the influence of the weather, interstratified with beds a few inches thick and from two to fifteen feet apart, of fine-grained grey shaly sandstone and bluish-grey limestone. The limestone bands are composed of comminuted organic remains, principally small corals, but in addition there were observed a small trilobite, a Leptena, an Orthis, and Ambonychia radiata. The sandstone bands hold Modiolopsis modiolaris—81 feet.

"2. Soft fine-grained bluish-grey calcareous sandstone, and finely arenaceous limestone, in beds from one to six inches thick. The surfaces are uneven —6 feet 4 inches.

"3. Measures concealed—80 feet.

"4. Mottled drab and gray soft argillaceous and finely arenaceous limestone, (the more calcareous portions being finely crystalline and grey). The beds are from one to six inches thick, in bands of from two to four feet, alternating with others of about the same thickness, of crumbling bluish-drab finely arenaceous shale, with nodular calcareous seams. Both the soft and hard bands are unevenly surfaced and of a nodular character. The fossils are Petraia, Stenopora fibrosa, Orthis lynx and a smaller species of Orthis, a large Atrypa, an Avicula, a Strophomena and an Orthoceras—26 feet 8 inches.

"5. Dark drab-grey soft brittle fine-grained arenaceous, somewhat crystalline limestone, in beds from one foot three inches to three feet six inches thick. It holds a small silicified Orthis—10 feet 6 inches.

"6. Greenish and bluish-grey soft finely arenaceous limestone in beds from one to three feet thick, separated by layers of bluish-gray shale from two to ten inches thick. The limestone holds nodules of white gypsum from two to three inches in diameter—27 feet 7 inches.

"7. Brownish soft unevenly-surfaced earthy-looking limestone, in beds of about two inches—8 feet 8 inches.

"8. Brownish-drab and grey limestone, in uneven beds from four to ten inches thick. Fresh fractures present a mottled drab and grey color, the grey patches having a crystalline and the drab an earthy appearance. The beds contain rusty cavities, lined with rhombohedral crystals of calcareous spar. The fossils are Stromatopora concentrica and Favosites Gothlandica. Near the top is a nodular shaly layer, holding iron pyrites, which, on decomposing, stains the face of the cliff with red oxide of iron—5 feet 3 inches.

"9. Brownish and drab-grey thin irregularly-bedded or shaly limestone holding Stenopora fibrosa, silicified and abundant, together with cavities lined with calc-spar crystals. This band forms the crest of the main escarpment—8 feet.

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(148) G.S.C., 1863, p. 171.

"10. Brownish and purplish-grey uneven surfaced limestone mostly in thin beds (the thickest being nine inches), Some of them are very dark and bituminous. The mass weathers yellow, and holds abundance of Stenopora fibrosa in a silicified state—37 feet 6 inches. Total, 291 feet 6 inches.

"This last mass (10) rises at a short distance back from the main escarpment in a second cliff above it, and, gradually approaching at a point half a mile nearer the head of the bay than the locality at which the previous portion of this section was measured, it joins the main escarpment, and is added to its height.

"About a hundred yards still farther back, and after an interval of concealment of about seventeen feet, a third terrace rises to the height of twenty-eight feet, but appears to gain in elevation as it recedes eastward. It consists of soft brownish and buff-grey thinly-bedded bituminous limestone, having a conchoidal fracture, and holding small irregular chalky nodules." (149)

Clinton Formation

The Medina formation is not present on the island, the Clinton resting directly on the Hudson River formation. The Clinton consists of from 125 to 150 feet of buff-weathering purplish-grey magnesian limestone, surmounted by a band of red marl, which may average 20 feet in thickness. This limestone is generally thin-bedded, and holds silicified fossils. In some places soft white nodules, similar to those found in the Clinton formation in the county of Grey, are met with in considerable numbers. This formation is well exposed near the northeastern extremity of South bay. From this point it sweeps round with a northward curve to the eastern shore of the island.

"The formation occupies a considerable area on the north side of South bay, and round the southern part of Manitowaning bay, forming the cliffs to the west and south of the village of the same name. At the southern extremity of the bay the usually thin-bedded character of the formation is interrupted by a massive section, forming the prominent part of the escarpment, known as Gibraltar Rock. Continuing to the westward, these limestones form the northern and northwestern shores of lake Manitou. Along the latter they rise in a cliff which in some places is upwards of 70 feet high. They cap the cliffs on both sides of West and Mudge bays, form the northern shore of lake Kagawong, and probably underlie the drift deposits at the north end of lake Mindemoya. They are again seen along the northern side of Bayfield sound, and upon Howe island, from which they cross Cape Robert, and are once more exposed at the entrance of Cemetery bay." (150)

The red marl band which separates the Clinton from the overlying Niagara formation probably does not average more than 20 feet in thickness, but is very persistent throughout the island.

Niagara Formation

This formation runs throughout the whole length of Manitoulin island, occupying the southern half. Its average breadth is nine miles, which with a dip of 40 feet in a mile would give 360 feet as the thickness of the formation; but its thickness may be 40 or 50 feet greater.

"The nothern boundary of the formation, rendered conspicuous by a limestone cliff varying from 20 to 200 feet in height, has the following course: After crossing the peninsula between the east end of the island and South Bay, it runs northward from Rocky Point on the northwest side of the same bay to the eastern extremity of lake Manitou, and thence follows its southern and western shores. It then runs out in a long point between the west end of Lake Manitou on one side and West Bay and Lake Mindemoya on the other. Starting from the northwest corner of this lake, it sweeps round in another promontory to the northeast corner of Lake Kagawong, and follows round its southern shore. From the west side of Lake Kagawong it crosses to Lake Mudgeemanitou, and after forming another promontory towards the north, runs southward to Lake Wolsey, reaching its east shore about the middle, from which point it continues round the southern part of the lake to the outlet. From Lake Wolsey it follows the south shore of Bayfield Sound, Sheshequaning, where it strikes across Cape Robert, and continues thence all along the shore to the western extremity of the island.

"The upper beds of this formation dip into the lake at so small an angle that they produce a low shore, and shallow water all along the south side of the island. The coast line is very much broken by shallow bays and straggling points, rendering navigation somewhat dangerous.

"The whole formation consists of thick-bedded and thin-bedded limestones of various shades of light and dark grey. Wherever the surface has been exposed to fire, by the burning of the timber, it weathers white, but when not thus scorched it is generally dark-colored or almost black, from the growth of small lichens upon it. The high promontory of Niagara limestone between Lake Manitou and West Bay suggested to the Indians the name, Metchkewedenong, or the high hill, for their village at the head of the bay. The following is an approximate descending section of the escarpment overlooking the west side of lake Manitou:

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(149) G.S.C., 18866-69, pp. 111-113.

(150) G.S.C., 1863-66, p. 173-4.

> "Very massive light grey magnesian limestone; in some places smooth walls, which had once formed the sides of joints, extend, without a break, nearly from top to bottom. No fossils are recognizable —60 feet.
>
> "Thin-bedded grey limestone, some portions holding silicified corals—40 feet.
>
> "Limestone similar to the last, but often projecting in a separate terrace below the other. A three-feet bed, near the centre, is full of silicified coral—50 feet.
>
> "Talus—30 feet. Total, 180 feet. . .

"On the south side of Bayfield Sound the rocks of this formation rise in a bold escarpment overlooking the lake. It is particularly conspicuous between Helen and Elizabeth Bays, and is separated by a step into two portions, the top of the lower being about 100 feet, and that of the upper between 200 and 250 feet above the level of Lake Huron. In crossing the island from north to south, after passing the brink of the main escarpment, smaller ones, making up the higher portion of the formation, are met with at intervals all the way to the south shore. They consist mostly of light grey, sometimes almost white, compact limestone, rather fine-grained and crystalline in texture. Some of the upper beds, being those on the south side of the island, are dark grey in color." (151)

St. Joseph Island

St. Joseph Island shows Trenton rocks on its north side. The Hudson River formation on this island is deeply covered with drift, and no exposures of it are seen. The base of the Clinton formation appears to skirt the south side of the island as far as Hay Point.

The following analyses, by Mr. Burrows, are of samples from Pollock's quarry, No. 1 being from the thick layer, and No. 2 from the lower argillaceous layer:

	1	2
Insol. residue	10.04	13.86
Ferric oxide	2.11	.90
Alumina	1.31	1.30
Lime	29.88	43.08
Magnesia	15.05	2.15
Carbon dioxide	40.56	35.99
Water	.90	.53
Sulphur trioxide	1.09	.89
	100.94	98.70

Cockburn Island

"Cockburn Island has a breadth of nine miles from north to south, and the dip of the strata being the same as the Grand Manitoulin, the thickness of the Niagara formation, of which this island is wholly composed, will here be about 400 feet also. Along the north shore of the island the rocks (which must be near the base of the formation) consist principally of soft buff-colored bituminous dolomites, suitable for building purposes. . . . . They are characterized by a conchoidal fracture, which, in natural exposures, parallel to the bedding, gives rise to a succession of small depressions resembling plates and saucers in size and form. These rocks were referred to in my last report as occurring at Meldrum Point (the northwestern extremity of Grand Manitoulin) . . . . Interstratified with these, on the north side of Cockburn Island, in some places there are found slaty and more bituminous bands of a dark color, and in others even-surfaced beds of a bluish-grey color, which, if not too soft, may be found suitable for flagstones. . . On the south side of the island the upper beds, consisting of grey somewhat bituminous limestone, are seldom seen, the shore being formed of sand and shingle; while on the east and west sides the limestones are exposed almost continuously along the beach. The beds are generally thick, some of them attaining upwards of six feet. Most of them are light grey in color and of a saccharoidal texture. In the interior of the island, especially towards the northern side, similar beds are occasionally exposed. They are, however, seldom seen in the form of cliffs, and, although the northern slope of the island is the most precipitous, much of it is buried under the drift." (152)

An analysis of the Cockburn Island limestone used at Sault Ste. Marie in the sulphite pulp process is given on a preceding page, under Pulp.

Quarries

The Ryan and Haney quarry, which is a few miles from Meldrum Bay village, was visited. It is the largest quarry on the island. A large amount of stone was taken from it for use in the construction of the canal at the Canadian Sault. Considerable care seems to have been used in selecting only the best stone for the work. The result is that over the three or four acres occupied by the quarry there is much stone blasted out ready for shipment, should a demand arise for this class of rock. The accompanying photograph shows the character of this broken stone. The edge of the quarry is about 100 yards from the water's edge, and the rock has been worked down to a depth of 5 or 6 feet. The rock is brittle and breaks rather irregularly, the bedding being uneven. The dock from which the rock was loaded on to boats lies opposite Green island, 8 miles from Mississagua light. The rock, which contains few fossils and has a crystalline aspect, is flat lying, and the road is paved with the strata in place for a mile or more north of the quarry. Vertical jointing is shown, and the glacial striae have a direction S. 25 degrees W., magnetic. The stone weathers to a light grey color. Analyses of samples taken from this quarry, representing the face, and the average of the loose pieces of rock, are given on a foregoing page.

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(151) G.S.C., 1863-66, pp. 174-176.

(152) G.S.C., 1866-69, pp. 114-115.

Some good building stone, to be seen in Mr. Wickett's farm house, occurs near Meldrum Bay, and it is also burned into lime, the layers free from chert appearing well adapted to this purpose. Analyses of this rock are given in the table.

The court house and registry building at Gore Bay are built of limestone quarried in the vicinity. These buildings were erected about 12 years ago. The stone weathers to a rather peculiar drab color. There are shallow quarries near the fair grounds. Just east of the grounds rock outcrops at the surface. Its thickest beds are 12 or 14 inches. A cliff on the street at the northwest corner of the grounds was sampled to a depth of 12 feet. Another sample was taken one-quarter mile west of this, on the road. The composition of these samples is shown in the table.

Samples of rock from the vicinity of Manitowaning village were obtained and subjected to analysis. The results are given in the table on page 75. The rock is used for building purposes, but no quarries of any importance have been opened up, surface rock being employed.

Analyses of samples from the following localities are also given in the table: Limestone at Manitou lake landing, 3 miles from Manitowaning, where the outcrop rises 6 or 8 feet above the level of the water; and from the upper 4 feet of the cliff at Manitowaning where the rock is rather thin-bedded and is followed by beds of similar thickness downwards of argillaceous and fossiliferous limestone.

The Manitoulin Portland Cement Company was incorporated during the past year. It is proposed to obtain the marl frome Ice lake, mix it with shale, and use the water fall at Kagawong to generate power for working the material up into cement. The fall is said to have a height of between 118 and 132 feet. At the roadside near the top of the hill at Kagawong a face of 12 or 15 feet of shale, with more or less limestone intermixed, is exposed. Samples of this and another exposure were taken, with the object of determining whether or not the material is suitable for cement purposes, should a works be established at the village.

Middlesex

The following logs of wells give an idea of the character of the drift covering and the underlying strata in this county.

"Some years ago a boring was made on the grounds of the Asylum [at London], which reached a depth of 2,250 feet, probably terminating in the upper portion of the Hudson River formation. The first rock met with is a limestone, at or near the summit of the Corniferous, as the shales, indicative of the Hamilton, found in the well at the sulphur spring in the western part of the city, are missing.

"The record of the boring, kindly furnished by Mr. W. Harris, of Petrolea, is approximately as follows (153) :—

Surface............	130 feet	
Limestone, hard...	200 "	Corniferous
" soft....	270 "	Onondaga with Guelph and Niagara if present.
" hard...	100 "	
"	600 "	
Salt and Shale.....	100 "	
Black shale........	200 "	Clinton
Red "	500 "	Medina
Limestone & shale..	150 "	Hudson River"

"One well in the township of Metcalfe, lot 24, concession 13, gave the following records (154) :—

Surface (clay).......	48 feet	
Black shale.........	75 "	Portage
Soapstone, etc.......	273 "	Hamilton
Limestone..........	104 "	Corniferous

"A well drilled on lot 5, concession 7, of the township of Mosa showed:

Surface (clay).......	50 feet	
Black shale.........	10 "	Portage
Soapstone, etc......	230 "	Hamilton
Limestone..........	262 "	Corniferous?"

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(153) G.S.C., 1890-91, p. 49 Q.

(154) Ibid, p. 52 Q.

Muskoka District

Although this district has a rough, rocky surface, limestones are very rare in it.

Robert's Bay Band

"Robert's Bay lies to the northeast of Prince William Henry or Beausoleil island, opposite to Penetanguishene. A narrow curving inlet runs northward from the bay, which the Indians call Anim-washing or Dog's Cave. The convexity in the course of the inlet is to the south-eastward. In thi inlet I discovered a band of light grey crystalline limestone, which is exposed on the points and islands along its course for a distance of about three miles, beginning at a quarter of a mile from the head of the inlet. The band has a thickness of at least fifty feet, and is overlain by thirty or forty feet of light grey granular gneiss, mostly thinly bedded, followed by an unknown thickness of very massive, close-grained, hard, brittle, silicious, gneiss. Its dip is to the east and southeastward, at an angle of about 70 degrees, the strike following the curves of the inlet, which, no doubt, owes its origin to the existence of the limestone. In this part of its course the band is evidently passing round the south-eastern end of an anticlinal. Near the head of the inlet, and again on one of the small islands at its entrance, the limestone is rich in several of the species of minerals which often charactrize the Laurentian limestones of the Ottawa Valley. Among them are brown idocrase in very fine crystals, salmon-colored garnets (well crystallized, but very brittle), dark wine-red garnets, hornblende, graphite, quartz, pyroxene in very numerous, small, transparent, bright green crystals, iron pyrites and mica." (155)

Nipissing District

Crystalline limestones of the Grenville series, together with Silurian limestones and marls, are found in a number of localities in this district.

Dr. A. E. Barlow gives the following account of the crystalline, or Laurentian limestones of the southern part of Nipissing :

"The most important band of crystalline limestone noticed in the whole district occurs at the foot of Lake Talon, an important expansion of the Mattawa River. The presence of this band was first noted by Bigsby (156) in 1820, and later in 1844, by Logan: Dr. Bell, in 1876, also gave a short description of its mode of occurrence (157). The rock consists of whitish crystalline limestone with small thickly dessenimated specks and patches of green serpentine. It is first noticed on the south side of the lake a short distance above the outlet, occupying the points along the shore, while the massive red granitite-gneiss rises into rounded hills behind. The limestone as far as can be ascertained on account of the massive texture of the gneiss, occurs as an interfoliation, dipping S. 8 degrees E. < 25. Farther down, towards the chute, the rock contains a good deal of serpentine in addition to some other impurities, and occurs seemingly as a large irregular rounded patch in the gneiss. At the narrows, a short distance above the Talon Chute, the contact [illegible] the crystalline limestone a[illegible] rather indistinctly foliated re[illegible] gneiss is well shown, the form[illegible] N. 74 degrees E. < 20 degrees, [illegible] latter, with a nearly east [illegible] strike overtops or flows over [illegible] of the crystalline limestone [illegible] tinct foliation of the gneiss co[illegible] in general with the line of jun[illegible] tween the two rocks. . .

"At the Talon Chute, there [illegible] two channels by which the lake discharges into the gorge below. The largest of the [illegible] channels is situated near the north side, while the southern one has been excavated along a band of ophicalcite seventy feet in thickness, intercalated with the gneiss and dipping in a southerly direction < 25 degrees.

"Smaller bands and patches of crystalline limestone, likewise occur on three of the Manitou group of islands in the eastern portion of Lake Nipissing. On the west side of the most southerly of these islands, beds of a beautiful [illegible] salmon-pink crystalline limestone occur containing radiating crystallizations of dark-green hornblende, black biotite, [illegible] yellowish-green epidote. The strike [illegible] about N. 80 degrees E., and the angle of dip is about 65 degrees. This is associated with the prevailing rather [illegible] grained dark-reddish and green granitite-gneiss.

"On the east side of the Great Manitou Island (Newman Island), a few chains south of the northeast point, there is a layer or bed of pinkish limestone, weathering yellow, reddish and greyish. The strike of the dark-red and green granitite-gneiss is about S. 60 degrees E., and the dip southeast, < 45 degrees. On the west side of the most easterly of the Manitou Islands, about the centre of the island, beds and patches of pinkish and whitish limestone are embedded in the dark-red and green granitite which has a strike N. 5 degrees E., and dip to the east of 45 degrees" (158).

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(155) G.S.C., 1876-77, p. 207.

156) Shoe and Canoe, Vol. I., London, 1850.

(157) G.S.C., 1876-77, p. 207.

Serpentine and Limestone

"Pigeon Lake.—The occurrence of serpentine at Pigeon Lake, on Montreal River (Ottawa Valley), is described by Prof. Bell in his report for 1875-76. He says: 'Pigeon Lake is upwards of five miles long. On its northeast shore, at one mile up, a fine-grained, greyish-red syenite occurs. About a mile further up the same side of the lake, there is a bluff of light greenish-grey, finely crystalline diorite, with disseminated grains of iron pyrites. A small island, in the middle of this lake, opposite this point, is composed of very dark green serpentine, with strings of calcspar and chrysotile. Fresh fractures have a somewhat mottled appearance, and occasionally present surfaces of a striated or finely columnar shining aspect. The natural surface has a rough or lumpy character and weathers to a rusty color. . . . . . in the next half-mile are two more islets in the middle of the lake. The rocks of these and of the southwest shore opposite, consist of similar and lighter green serpentine, largely mixed with calcspar, constituting, in fact, a sort of limestone in the third islet. In some parts the serpentine is divided into separate pieces by thickly reticulating strings and veins of crystalline and granular light-grey calcspar, leaving the latter scattered as angular fragments through the mass.'

"The characters given by Professor Bell, it may be observed, might be applied almost word for word to some of the serpentines of the eastern townships, which are known to contain varying admixtures of carbonates, passing here and there into limestones or dolomites, and in some instances to have a brecciated structure like the last variety described in the above extract. The Pigeon Lake serpentine also resembles those of the Townships in containing chromium and nickel. A specimen of the rock from the island first mentioned, gave, on analysis the following results:

Silica	34.591
Alumina	2.391
Chromic oxide	0.382
Ferrous oxide	8.660
Manganous oxide (with a little nickel and cobalt)	0.244
Lime	3.625
Magnesia	32.253
Grains of chromic iron	0.280
Water and carbonic acid, by loss	17.574
	100.000

"The color was blackish-green, mottled with olive-green, the fresh fracture splintery and mostly dull, but here and there presenting shining surfaces. In places the rock is traversed by minute veins, consisting of carbonates of lime, magnesia and iron. In the above analysis the carbonates were not separated, but another fragment of the rock yielded to acetic acid in the cold 21.378 per cent., the proportions of which, calculated for a hundred parts, were as follows:

Carbonate of lime	37.90
Carbonate of magnesia	51.95
Carbonate of iron	10.15
	100.00

"The carbonate of magnesia is considerably in excess of what would be required to form dolomite with the carbonate of lime, so that there must be some magnesite present, and the rock is either a dolomitic or a magnesitic ophiolite." (159)

The same locality is again mentioned in the following quotation:

"These three kinds of rocks (serpentine, steatite and dolomite) may be mentioned among those which occur in minor volume in the Huronian system. Serpentine has not yet been found at all within our present region, but some exposures of it were met with at Pigeon lake on the west branch of Montreal river, a short distance to the northward. The serpentine occurs by itself, or associated with calcspar, or passing into limestone, on some small islands in this lake.

"On the shores in the vicinity are fine-grained and massive reddish-grey quartzite, greenish-grey clay-slate, fine-grained reddish grey syenite, light greenish-grey finely crystalline diorite, with disseminated grains of iron pyrites and grey porphyry very thickly speckled with opaque-white crystals of felspar and a few of shining black hornblende. The serpentine on fresh fracture shows different shades of green, and is somewhat mottled. Under the weather the natural surface becomes rough and of a rusty color. It contains oxide of chromium, both in the form of small grains and in chemical combination with the rest of the rock, and thus resembles the serpentines of the Eastern Townships in the Province of Quebec. The writer has been shown specimens of serpentine said to have been collected among the Huronian rocks some miles north of Pigeon lake. On the point about the middle of the west shore of Abitibi lake the late Mr. Walter McOuat of the Geological Survey met with dark green serpentine, weathering dull white, strongly magnetic and containing grains of chromic iron. Mr. E. B. Borron informed the writer that he had heard of serpentine having been found in the country lying north of the west end of Abitibi lake. . . . . .

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(158) G.S.C., 1897, pp. 89, 90, I.

(159) G.S.C., 1876-77, pp. 483-484.

"Dolomites or magnesian limestones, having certain characters in common, occur sparingly in the Huronian system in the most widely separated areas of these rocks. They are usually fine grained to compact, silicious and marked by strings and fine threads of quartz and sometimes of calcspar, which have commonly a reticulating arrangement. Most of them are ferruginous, and the weathered surface is generally yellow, brown or red, but sometimes grey or black. The iron is often present in large enough proportion to form a spongy crust of the oxide. Occasionally these dolomites become rather finely crystalline, like saccharoidal marble, and nearly white. In our present region they have never been traced far on the strike, although they attain from 100 to 300 feet in thickness.

"Midway up the northeast side of Pigeon lake, already mentioned, on the west branch of Montreal river, there is a bluff thirty feet high of semi-crystalline, yellowish-gray limestone, mottled with green and reddish-brown patches and full of reticulating strings of white calcspar. The weathered surface has a ferruginous crust, from one-half to one inch thick, showing the rock to contain a large proportion of iron. A thickness of upwards of one hundred feet of the limestone is exposed at this place, and it continues northward along the shore for a quarter of a mile or more. The other rocks in the vicinity of this dolomite consist of syenite, diorite, serpentine, porphyry and different varieties of quartzite.

"On the eastern side of South bay, lake Wahnapitae, and thence around the promontory towards Outlet bay, Mr. Alexander Murray described a calcareous breccia associated with quartzites and greenstones. . . . . .

"A band of magnesian limestone occurs at Island Portage on Wahnapitae river, about four miles below the outlet of the lake of the same name. It has a width of at least 300 feet across its general strike, but owing to the undulation of the strata, the true thickness of the band could not be determined. On fresh fracture it is mostly light greenish-gray in color, fine grained, soft, somewhat impure, and weathers to a brown color. The weathered surface in some parts is marked by small corrugated ridges, like that of the Huronian limestone of Echo lake, which result from the weathering out of minute silicious streaks following the bedding. An exposure of the limestone at the head of Island Portage shows a more massive variety with a brownish gray color on fresh fracture." (160)

Palaeozoic Limestones

Small isolated areas or outliers of Palæozoic rocks are found at two or three localities in the district of Nipissing. These have been described by Logan, Murray, Barlow and other writers. No economic use has been made of the Lower Silurian limestones which occur on a number of the islands in lake Nipissing. The Upper Silurian strata, Clinton and Niagara, at the head of lake Temiskaming, have been quarried for lime, and the rock has been used for foundation stone and for the walls of one or two buildings in the villages on the shores of the lake. Recently the stone quarried in the vicinity of Haileybury village has been used in construction of culverts along the line of the Temiskaming and Northern Ontario railway. Stone of good size and quality is obtainable at a number of points.

These limestone strata are likely to be of great importance as the large areas of agricultural lands to the north and west are now being rapidly settled. Limestone is found at few places in the district, and the freight on material from the quarries to the east, down the Ottawa valley, or to the south will prohibit competition with the Temiskaming quarries. The stone here, which is of a suitable quality, will be required for burning into lime, for buildings, for railway structures, and possibly for metallurgical and other uses. It will be seen, however, from the analysis given below, that on account of the presence of magnesia there are some uses to which these limestones and the lime produced therefrom are not adapted. If lime carrying a high percentage of calcium carbonate is required it will either have to be brought from a distance, or, it is possible that marl from some of the lakes in the district can be utilized.

Dr. Barlow gives the following description of the Palæozoic limestones and the associated strata of the district:

Chazy, Birdseye and Black River

"On the west side of Iron island in lake Nipissing, beds of chocolate-brown and yellowish-gray, coarse sandstone or grit, occasionally becoming a fine conglomerate, rest unconformably on the upturned edges of the gneissic rocks classified as Laurentian. The rock is composed of loosely compacted and rounded grains of quartz, more or less abundantly coated with hydrous oxide of iron with little or no interstitial material. The lowest beds are of a brown color, with occasional lighter spots from which the iron oxide has been removed, while higher beds are yellowish-gray, also showing lighter colored areas. When subjected to the action of the weather, curious subspherical rings suggestive of concretionary action appear on the exposed surface, but a close inspection shows no apparent difference either in composition or texture of the part where these are developed. The beds are of good thickness, but would be useless for building purposes on account of the loose and friable nature of the sandstone. Little or no calcareous matter is present, which is a rather unusual feature, as even the coarse arkose or conglomerative lying at the base of the Manitou islands outliers contains a considerable admixture of carbonate of lime. Murray mentions the finding of loose fragments of limestone with characteristic Chazy fossils that possibly overlies these sandstones, which may thus represent the basal portion of the Chazy formation.

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(160) B.M., Vol. I., pp. 81-82.

"The Manitou islands, five in number, are situated about the middle of the wide open space in the eastern part of the lake. The largest and most northerly of these islands is about a mile in length from east to west, and is known as the Great Manitou or Newman's island. The next in size and importance is the little Manitou or McDonald's island, while the other three are so small and insignificant that they have not been separately named.

"The most southerly of these islands is somewhat less than a quarter of a mile long, but only a few chains in width. On the southeast side of the island is a dark brown arenaceous limestone, containing angular or subangular fragments and pebbles of the subjacent gneiss. This rock is of no great thickness, and passes rapidly upward into a yellowish-grey arenaceous limestone. The whole section exposed is of small extent and thickness, the beds lying in nearly, if not quite, horizontal succession. The shore is strewn with large angular blocks of the coarse-grained, yellowish-gray, arenaceous limestone, containing many weathered and water-worn fragments of obscure cephalopod-like remains. These fragments, according to Dr. H. M. Ami, who has examined them, resemble Endoceras multitubulatum (Hall) from the Trenton and Black River.

"McDonald's island, or the Little Manitou, is about half a mile in length from north to south, and of no great breadth. At the southwest corner is a small patch of yellowish-gray limestone, occurring in beds which have little or no inclination. The only fossil remains visible at this locality were fragments representing chiefly the siphuncles of orthoceratites together with crinoid stems and casts of supposed worm-burrows. Small outlying patches were also noticed beneath the surface of the water.

"About the middle of the island, on the west shore, the thickest exposure of the whole of these outliers is exposed. The total thickness is about thirty feet, the beds showing a gentle inclination to the west. At the base is a greenish or yellowish arenaceous limestone holding decomposed fragments and pebbles of the gneissic rocks beneath. This is overlain by a yellowish, arenaceous limestone, comparatively free from coarse fragmental material, which in turn gradually passes upward into grey limestones and shales holding numerous fossil remains. The orthoceratites are characteristic and numerous, and one specimen obtained must have belonged to an individual over six feet in length.

"Small exposures of the basal conglomerate and overlying arenaceous limestone occur on the west side of the Great Manitou Island, these rocks dipping south 5 degrees, while on the south shore, near the old wharf, is a small outcrop of arenaceous limestone dipping east at a low angle.

Trenton

"Between Deux Rivieres and Mattawa are several small comparatively flat-lying exposures of sandstones and limestones resting upon the Laurentian gneiss close to the edge of the river, that are completely covered during times of freshet. The sections exposed are of no very great thickness or extent, the beds dipping in a southerly direction at a low angle. The most important of these outliers is the one situated on the north side of the river, about four miles above Deux Rivieres. The basal or sandstone beds formerly furnished material for the manufacture of grindstones of an excellent quality, while local lime-kilns utilized certain portions of the higher beds exposed in this escarpment.

"About six miles below Mattawa two small outliers of a light-yellowish and purplish, gray-weathering arenaceous limestone are seen in the north bank of the Ottawa river, containing abundant fossils characteristic of Lower Trenton period. Besides the rock in situ, the beach in the vicinity of these outliers contains a large number of somewhat water-worn blocks of these fossiliferous strata.

Clinton and Niagara

"The rocks of this age, exposed on the shores and islands of the northern portion of lake Temiskaming, have been of exceptional interest to geologists ever since their discovery and description by Logan in 1845. Geographically, this outlying patch is so widely separated from any locality where rocks of similar age are now known to exist, that it has been a question whether it is indicative of an area of marine submergence connected with that in which the fossiliferous strata of Hudson Bay were deposited, or whether it was in some way connected with the Niagara basin to the southwest. It has been previously asserted that these rocks belong rather to the great northern trough connected with Hudson Bay, of which they are probably an outlier, and the absence of all strata of Niagara age in the region bordering the lower Ottawa has served to strengthen this belief. Although in lithological character and color the rocks of similar age exposed on Temiscaming exhibit a marked similarity to the Niagara exposed further to the north, the rich and varied fauna characteristic of this outlier presents no corresponding resemblance, but rather a close analogy with the Niagara formation of southwestern Ontario.

"It has been shown that a pronounced similarity exists both in lithological character and fossil remains between the Niagara of the Winnipeg basin and that exposed in the vicinity of the Churchill on Hudson Bay, although these areas are now widely separated, while both present organic forms that are entirely lacking in the Temiscaming outlier. These facts, therefore, seem to prove that the seas in which the Niagara sediments of the Winnipeg basin and of Hudson Bay were deposited were practically continuous, while both were separated from the Temiscaming basin and the region to the southwest.

"The strata forming the Temiscaming outlier occur in the form of a shallow synclinal trough, occupying somewhat more than the breadth of the lake, which is here about six miles, and extending from the northern end of Moose or Bryson Island, north-westward beyond the confines of the present map. On both sides of the lake the rocks incline towards the water at varying angles, depending on the character of the shoreline; although in general the dip does not exceed 10 degrees, and angles of lesser amount are far more common. On Mann or Burnt Island, as well as on the peninsula to the north, the limestones show a very gentle westerly inclination of between one and two degrees, while on Percy Island, near the west shore, the rocks are very nearly if not quite horizontal. It is thus evident that any section made must of necessity be more or less ideal, and any thickness based on the observed angles of the dip is sure to be misleading. The whole thickness exposed in any one section is somewhat less than 150 feet, and it seems certain that the total amount of the Niagara exposed on this lake cannot be greater than 300 feet, and may be considerably less. The occurrence of loose angular fragments and slabs of grayish dolomite, resembling that exposed in the vicinity of Lake Huron and Nipissing and containing characteristic Trenton fossils, has been noticed. These are distributed at several points on the shores of the lake, and specimens were collected from the northeast shore of Chiefs Island. Although their source has not yet been ascertained, the angular character of the fragments and their abundance shows clearly that this cannot be far distant. The lake is here over 200 feet in depth, and it is just possible that below the Niagara limestone and concealed beneath the waters of the lake there exists an area of Cambro-Silurian rocks. This, however, can only be ascertained by boring, as no exposures of these rocks were encountered, although a diligent search was made with this object in view.

"The relatively smaller quantity of conglomerates and sandstones, characteristic shallow water deposits, and the rapid alternation from these coarser clastics to the fine-grained limestones indicative of deep water deposition, point to a rather sudden marine invasion; while the comparatively great volume of strata remaining shows a prolonged submergence. The fine-grained character of most of the limestones show that their deposition took place in a quiet arm or extension of the sea, not affected by the open ocean, while the abundance and character of the fossil remains are ample testimony of the genial character of its waters.

"As exposed on the west side of Wabis Bay, in the northwest corner of the lake, the lower portion of this formation is composed of a loosely coherent sandstone or grit alternating with thinner beds of a fine conglomerate, with pebbles chiefly of Huronian quartzite, most of which have a thin coating of yellowish or brownish iron oxide, while the matrix consisting of similar material in a finer state of division, contains a slight admixture of calcareous matter. The actual contact between this and the underlying slate of the Huronian is not seen, although only a few yards intervene between the exposures of the two rocks. The existing relations can, however, be made out pretty clearly, for while the compact and rather massive slaty rock which here represents the Huronian occurs in exposures with more or less rounded or hummocky outlines, the arenaceous strata of the Niagara dip off or away from these hillocks at an angle of 5 degrees.

"At Haileybury, on the western shore of the lake, close to the water's edge and cropping out from the shingle is a small exposure of light-yellow fine-grained limestone, without visible fossil remains, dipping northeast 25 degrees. The discovery of limestone with the general contour of the country in its vicinity, seem to suggest that a small patch of Niagara extends northerly along this shore towards Wabis Bay, being perhaps three miles in length by about a quarter of a mile in breadth, underlying the clay which here effectually conceals any rocks which may be beneath.

"Further south, on Percy Island, which is only a few chains in length and is separated from the western mainland by a very shallow and narrow channel, the rock exposed is a light-yellowish limestone, presenting a very uneven or cavernous surface as a result of unequal weathering. The strata are nearly if not quite horizontal and weather from yellow to brown or almost black, as a result of the iron present. Shells of various species of brachiopods are somewhat numerous.

"This fauna represents the Clinton or base of the Niagara or lower part of the Silurian.

"The northern and western points of Chief's Island rise into comparatively high ridges of massive quartzose sandstone or quartzite-grit, which present the usual rounded and glaciated outlines. Sheltered in the bay intervening between these two points is a small patch of boulder conglomerate, composed of subangular masses derived from the underlying quartzite. These are embedded in a calcareo-arenaceous matrix composed chiefly of pebbles and finer material, the whole representing evidently a boulder-strewn beach covered by later sediments of the Niagara formation. The surface of the quartzite on which this conglomerate rests, presents the hummocky character so common in the case of the hard Archæan strata, the irregular cracks and depressions being filled by the conglomerate. Subsequent glaciation has removed much of the material, so that the exposure now presents a plane surface with a more or less net-like structure, the framework being represented by the finer arenaceous cement, while the meshes or interstices are occupied by truncated sections of quartzite boulders as well as of the rounded hillocks of the solid rock beneath. Some of the boulders present in this conglomerate were evidently large concretions, as they exhibit concentric structure and weather very rusty, owing to the disintegration of the large proportion of iron present. The finer cementing material, while relatively much smaller in amount than the pebbles and boulders, is always of a greenish or yellowish color and frequently contains corals and orthoceratites. The action of the weather has partially obliterated the glacial striae on this finer matrix, but the sections of the quartzite boulders and hummocks exhibit these markings in great perfection.

"On the south-western shore of Chief's Island, is another small patch of a finer grained conglomerate, the pebbles of quartzite being less numerous and of much smaller size, while the matrix contains much more calcareous matter. The rock dips south-east < 5 degrees.

"A number of rather badly-preserved fossils were secured at this locality. . . . which represents the Clinton formation or lower portion of the Niagara.

"On the east side of the lake, from a point south of Chief's Island to within less than a quarter of a mile from Piche Point, the shore is occupied by a narrow fringe of the basal conglomerates and sandstones of the Niagara. The coarser beds are of the boulder conglomerates already described, representing simply a talus of angular and sub-angular fragments detached from the elevations in the immediate vicinity of the exposures, consolidated together by a finer-grained arenaceous cement of a yellowish color, in which are also embedded fragments of corals and orthoceratites.

"This boulder conglomerate passes upward into a fine conglomerate, in turn replaced by a coarse grit, and becoming finally a yellowish, rather friable sandstone. These beds run in long undulating curves, closely following the general outline of the underlying quartzite with a general westerly dip at angles varying from 10 degrees to 15 degrees. The action of the waves has in places caused this to disintegrate very unevenly, leaving a rough pitted surface. At Piche Point and for some distance north the Huronian quartzite is left entirely denuded of these deposits.

"In the bay to the south of Piche Point and between this and Wright's silver mine, there are two small patches of thinly-bedded light yellow arenaceous limestone, dipping in a southerly or south-westerly direction, 5 degrees, immediately south of Wright's mine is another small patch of similar arenaceous limestone, dipping south-west < 9 degrees.

"On the east shore of the lake, nearly opposite Bryson Island, there are two more small patches of the arenaceous limestone exposed at the shore, wrapping round the hummocks of Huronian quartzite and dipping in a southerly or south-westerly direction < 5 degrees. None of these small patches of limestone contained any visible fossil remains.

"On Burnt or Mann Island, as also on the two smaller islands between this and Bryson Island (Oster and Brisseau islands), as well as on the high promontory separating Wabis and Sutton bays in the northern part of the lake, are exposed the limestones and shales that represent the deep-water deposits of this period. The limestone is of a pale-yellow or cream color, weathering whitish, and varies in thickness from a few inches up to two feet or over. Some of the beds are very fine-grained and of rather even texture, and it is possible that some parts may prove to be sufficiently uniform for use as lithographic stone. As a building stone, it is of excellent quality. These limestones, on the north shore of the lake at Dawson Point, dip a little south of west, at an angle of between one and two degrees, rising into cliffs of over a hundred feet in height on the west side of Sutton Bay, and forming a somewhat elevated rocky plateau with a gentle westerly slope, corresponding mainly with the angle of dip towards Wabis Bay. The east shore of Mann Island presents a somewhat similar, though much lower escarpment, while the western shore is a gently shelving beach, which at low water reveals considerable areas of the almost horizontal limestones. Some of the beds contain a considerable proportion of silica of a cherty character, and all the fossils are more or less silicified. The action of the weather causes them to stand out in relief, and often displays their minute structures perfectly. A large collection of these fossils was made along the western shore of Mann Island." (161)

The following is an analysis of a sample of the rock from Farr's quarry, Haileybury, Silurian limestone:

Insoluble residue...	1.60
Ferric oxide, and alumina... ...	.66
Lime...	29.50
Magnesia	21.59
Carbon dioxide...	46.84
Sulphur trioxide	.70
	100.80

Shell Marl

"Deposits of this kind are frequently found below accumulations of peat, the marl in these instances being, therefore, of not very recent formation, but in other cases it is found to be still in process of deposition, covering the bottoms of shallow ponds or lakes.

"Emerald Lake, about five miles west of the Opimika Narrows, is at the head waters of one of the branches of Opimika Creek, which reaches lake Temiskaming from the west immediately above the Opimika Narrows. This creek, as well as the lakes which it empties, are remarkable for their clear water. Emerald Lake itself is comparatively insignificant in size, being only about half a mile in length by a quarter of a mile in greatest width at the southern end, gradually tapering towards its outlet at the northern extremity. The lake is in a small valley, from eighty to one hundred feet in depth. At the south-east corner is a very shallow bay, affording entrance to a stream, which is fed by a number of large cold springs, that rise at the base of an amphitheatre-like gully, at the base of steep banks, composed mainly of sand and gravel. The water of the bay, although so shallow, is very cold, even during the hottest days of summer, while the whole bottom is covered with a deposit of shell marl of unknown depth. That this depth is considerable there is no reason to doubt, as the soundings made with long poles failed to reach the bottom of the deposit. Besides this bay the whole lake contains marl deposited on the bottom, while the pebbles and boulders near the outlet show a considerable coating of this loosely-coherent, earthy carbonate of lime. The water of these springs is evidently calcareous, and is found to be slightly aperient.

"According to Mr. J. F. Whiteaves, who has examined the specimens of fresh water shells obtained from this locality, the species represented are Sphoerium sulcatum (Lam.), and Planorbis Trivolvis (Say) var. Macrostomus (Whiteaves).

"A sample of the marl examined in the laboratory of the Survey was found to have the following composition.

	Per cent.
Hygroscopic water (after drying at 100 degrees C.)...	1.06
Lime...	48.32
Magnesia...	0.04
Alumina...	0.07
Ferric oxide...	0.08
Manganous oxide...	traces.
Potassa...	"
Soda...	"
Carbonic acid.......	38.01
Sulphuric acid...	0.07
Phosphoric acid	0.02
Silica, soluble	0.10
Insoluble mineral matter...	8.62
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water....	4.79
Total...	100.12

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 86.28 per cent. of carbonate of lime. The insoluble mineral matter was found to consist of:

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(161) G.S.C., 1897, pp. 120-128 I.

	Per cent.
Silica	6.24
Alumina and ferric oxide	1.51
Lime	0.29
Magnesia	0.08
Alkalies (?)	0.50
Total	8.62

"Marl is often used as a fertilizer, and deposits such as that exposed at Emerald Lake should be of value locally for this purpose." (162)

Norfolk

There are frequent exposures of the limestones of the Corniferous formation in the townships of Woodhouse and Townsend.

"To the west of the Grand River, in the counties of Haldimand and Norfolk, the Corniferous limestones are often seen resting on the Oriskany formation, and forming small eminences; which present escarpments, with the sandstone at their base. These limestones are here of a drab color, and abound in chert. The organic remains with which the strata abound, are entirely silicified in many of the beds; while in others they have undergone no such change. . . .

"Higher in the series, along the same line of country, blue limestones, sometimes to the amount of 20 feet, with grey beds in less volume, are associated with cherty layers and interstratified with bands of a drab-colored limestone. These strata are sometimes quarried, and yield stone fit for building purposes." (163)

"It is remarked by Mr. DeCew that in the southwest corner of Windham, and along the east side of Middleton, very large boulders of Devonian limestone, probably belonging to the Corniferous formation, are of frequent occurrence, associated with others of Laurentian origin. In the latter township, the limestone masses are not found on the west side of Big Creek, while those of Laurentian rocks continue to be as abundant as before." (164)

A sample of limestone from lot 17 in the third concession of Woodhouse township, analysed by Mr. Burrows, had the following composition:

	Per cent.
Insoluble matter	5.77
Ferric oxide	.50
Alumina	trace
Lime	47.66
Magnesia	3.99
Carbon dioxide	41.73
Sulphur trioxide (SO_3)	.50
Loss, water, etc.	.21
Total	**100.36**

"At Villa Nova, lot 18 in the eighth concession of the township of Townsend, is an excellent exposure on which a quarry has been opened. About eight feet are here exposed, the upper three being a silicious hornstone with corals, and the lower five, banded limestone with numerous fossils. The best stratum for building purposes is eight or ten inches in thickness, the last layer exposed being bluer, harder and less fossiliferous than the overlying seams. One band in particular is so filled with corals and is so clean and compact that it should cut and polish to a handsome ornamental stone. A number of fossils were collected here.

"For some distance south of Villa Nova the rock is quite close to the surface and crops out at several places. At Rockford, lot 22 in the ninth concession of Townsend, are considerable exposures of coralline limestone bearing many other fossils, conspicuous among which are masses of Stromatopora. The exposures are some acres in extent, with the fossils well weathered out and lying on the surface of the fields, particularly where a small stream has aided in the disintegration of the rock. About 20 feet are exposed in all. Some flint of a reddish color is attached to many of the corals and much resembles that at Villa Nova." (165)

Northumberland

"The summit of this mass of strata [of the Trenton group], crosses Crow River at the fall, north of the town line of Marmora and Rawdon, with a slope of 42 feet in a mile. The river here flows on the axis of an undulation, on which 22 feet of the same beds again come to the surface, resting on a protrusion of Laurentian syenite in Rawdon, on Laurentian iron ore at Allan's Mills in Seymour, two miles farther down, and on fine-grained augitic trap, still two miles beyond. Large fragments of the trap, cemented together by limestone, form a brecciated bed at the base of the fossiliferous rock. Near its junction with the trap, the Silurian limestone assumes a variety of colors, red, orange, blue, green and yellow; and it sometimes happens that all these colors are displayed on one surface, giving an appearance a good deal resembling rude mosaic. In the strata south from the trap, the black chert, and the silicified fossils blackened with vegetable matter, lie on a ground of white-weathering limestone in great abundance. . . .

"The banks of the Trent below Healey's falls, which are a little above Crow Bay, at the junction of Crow River, rise in vertical limestone cliffs sometimes upwards of 40 feet, the strata of which are filled with the fossils of the Trenton formation. The lowest beds of the cliffs are from 4 to 8 inches thick, the surfaces being thickly studded with black weathered fossils, chiefly an Orthis. Above these beds is a strong one about 3 feet thick. . . The rest of the exposure consists of dark grey or blackish and blue limestones, alternating with dark green calcareo-argillaceous shale. These beds are very fossiliferous. . . . From Crow Bay to Ramsay's falls, on the ninth lot of the sixth range of Seymour, a distance of about four miles and a half, the measures accumulate at the rate of about 40 feet in a mile; and at the latter place they rise in vertical cliffs on each side of the river to the height of 40 or 50 feet. All the beds are filled with Trenton fossils, and some are almost a mass of Leptaena sericea . . .

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(162) G.S.C., 1897, pp. 155-157 I.

(163) Ibid, 1863, pp. 368-371.

(164) Ibid, pp. 894-5.

(165) B.M., Vol. VII., pp. 142-43.

"Between Peterborough and Rice Lake, the Otonabee nowhere exhibits a rock section, nor was there one observed at any place between Rice Lake and the shore of Lake Ontario at Cobourg; but at the latter place and between it and Port Hope, there are some small exposures of blackish-grey thin bedded nodular limestone and shale, which, among other Trenton fossils, hold Lingula Canadensis and Asaphus megistos." (166)

"From the Moira river the Trenton [formation], continues along the north side of the bay of Quinte, and is well seen in low-lying ledges in rear of the town of Trenton." (167)

Ontario

The following paragraphs dealing with the limestone exposures of Ontario county are taken from the Reports of the Geological Survey:

"The farthest up exposures of Trenton limestone, near the lake shore, occur about a mile south of the village of Oshawa, in Whitby, where the dip is N. 5 degrees." (168)

"Between Balsam Lake and Lake Simcoe, a distance of nearly thirty miles, the detailed distribution of the outcrop of the formations [Trenton group], which we have been tracing, has not been ascertained. The base of the series is supposed to be limited northward by the south branch of the Black River, a tributary of the Severn. It comes upon the east side of Lake St. John, in the fifth range of Rama, and continues from the west side to a cove in Lake Couchiching, on the thirtieth lot of the lake front. Crossing this lake, it would strike the fifth lot of the tenth range of Orillia, where it is concealed, and pass to the mouth of the Coldwater in Matchedash Bay.

"On Lake St. John the lowest Silurian beds, not far removed from the Laurentian gneiss, consist at the base of a yellowish fine-grained and somewhat arenaceous limestone, passing in a few feet to a drab-colored, compact limestone with a conchoidal fracture, some of the strata resembling the Marmora lithographic stone. The thickness seen is about twenty feet. Fossils are rather scarce in the rock, and somewhat obscure. . . In one of the beds, the fossils are coated with a leek-green mineral, and the same substance invests what appear to be very small fissures in the rock. On Lake Couchiching there is exposed above the water nearly the same thickness of a similar limestone, which is quarried for building and lime-burning, for both of which purposes it is well suited. . .

"On the east side of Lake Couchiching these beds reach the line between the townships of Rama and Mara, where they become covered over with drift, so that their precise summit has not been determined. Proceeding southward, the strata, after an interval of concealment, are again exposed in Mara, striking to the northward of east, and coming upon the banks of the Talbot River, about three miles and a half from the lake shore. The sections are seldom over five feet in thickness, and a better display exists at the northern extremity of Canise Island, opposite the mouth of the Talbot, where the beds present an aggregate of ten feet over the water's edge. The upper layers are thin, coarse, and irregularly deposited, but the lower ones are thicker, and afford good limestone for burning. This locality, with those on the Talbot, is very fossiliferous, the species being such as characterize the Trenton formation.

"A ridge of the Trenton formation is met with near the Beaver River in Thorah, and on Graves Island, which is considerably to the south of Canise, are to be seen some calcareous rocks, which are probably pretty high up in the series. Southeastwardly, similar beds strike the main shore on the twenty-second lot of the first range of Thorah, not far from the lake corner of Brock; and it is said that similar limestone is met with on the twenty-third lot of the eighth range of the last-mentioned township. On the former lot, the beds are from three to eight inches thick, and constitute an aggregate of ten or twelve feet over the surface of

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(166) G.S.C., 1863, pp. 187-189.
(167) Ibid, 1901, Sum. Rept. p 178.
(168) Ibid, 1863, p. 189.

Lake Simcoe. They yield excellent lime when burnt, and are occasionally fit for building. At this place a favorable opportunity is afforded to determine the dip. It would appear to be south-westerly, and as the strata seen on the lake shore crop out about half a mile from it, where they stand at a height of thirty feet over the lake, the difference between this and their height at the margin would be about eighteen feet so that the slope may be taken as something between thirty and thirty-five feet in a mile. This would give a volume of about 150 feet for the Birdseye and Black River formation on Lake Couchiching, and from 500 to 600 feet for the Trenton formation on Lake Simcoe. The country to the southward of the exposures mentioned being covered over with drift, it is difficult to say whether this would comprehend the total thickness." (169)

"Prof. E. J. Chapman has described bright green streaks and markings in beds of a silicious limestone of the Black River formation in the township of Rama. The green matter is said, in some cases at least, to be collected around minute crystals of decomposed iron pyrites. It was supposed from its color to be a compound of copper, but according to Prof. Chapman, it contains no traces of this metal. Silica, oxide of iron, and water were however detected in its composition, so that it is probably related to glauconite." (170)

"A dove-colored limestone of the Black River formation from Lake Couchiching is fine-grained, homogenous, compact, with a conchoidal fracture, is translucent on the edges, and resembles in aspect some hornstones. It is a nearly pure carbonate of lime, containing however 1.27 per cent. of carbonate of magnesia, and 1.17 per cent. of insoluble matter, of which .8 per cent. is soluble silica." (171)

Marl

"From Chalk Lake, lots one and two of the first, and lot one of the second concession of the township of Reach, ... The lake has an area of about seventy-five acres. The marl, which forms the bottom of the lake, is apparently of considerable thickness, but its exact measure has not been ascertained.

"The air-dried material is earthy, somewhat coherent; color, yellowish-white. It contains root-fibres and some shells.

"An analysis by Mr. F. G. Wait showed it to have the following composition: (after drying at 100 degrees C.—Hygroscopic water, = 0.01 per cent.):

Lime	51.88
Magnesia...	0.07
Alumina...	0.09
Ferric oxide...	0.08
Potassa.	traces.
Soda.	"
Carbonic acid	40.86
Sulphuric acid...	0.06
Phosphoric acid....	0.01
Silica, soluble...	0.05
Insoluble mineral matter... ...	2.11
Organic matter, viz., vegetable fibre in a state of decay and products of its decay, such as humus, humic acid, etc., and possibly a little combined water...	4.77
	99.98

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 92.64 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of: (172)

Silica....	1.57
Alumina and ferric oxide ...	0.38
Lime	0.06
Magnesia	0.02
Alkalies (?)	0.08
	2.11"

Longford Quarries

The Longford are among the most important limestone quarries in the Province. Formerly quarries were operated here by a number of companies or individuals, but they were consolidated under one management in 1901. The quarries are on lots 20 to 28, front range, of the township of Rama. The stone has been used in the King and Queen street subways in Toronto, the date stone in the former being from the yellow layer mentioned below. It was also used in the foundations of the Parliament buildings and city hall, Toronto, and in the Hamilton tunnel of the Toronto, Hamilton and Buffalo railway. It is being constantly used by the Canadian General Electric Company of Peterborough as they extend their works. The Grand Trunk railway uses the stone for their work in Toronto and Hamilton. It has also been employed as a flux at the Midland blast furnace. A small amount of the rock from the top layer is used for burning into lime at the quarry

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(169) G.S.C., 1863, pp. 191-3.

(170) Ibid, p. 488.

(171) Ibid, p. 621.

(172) G.S.C., 1894, p. 26 R.

The company operating the quarries is known as The Longford Quarry Company, Limited, the officers of which are J. B. Tudhope, president, G. Thomson, vice-president, and A. McPherson, secretary-treasurer. The company advertise "all kinds of building, bridge and dimension limestone always on hand." The following are given as the results of crushing tests of the stone from these quarries, made by the Department of Public Works of Canada, November, 1895.

"Sample No. 1 :—"Area exposed to crushing, 2.9 inches by 3 inches, equals 8.7 square inches.

"Height of sample, 3 inches.

"Ultimate crushing load, 181,000 pounds.

"Crushing strength per each square inch, 20,805 pounds.

"Sample No. 2 :—"Area exposed to crushing, 3.4 inches by 3.4 inches, equals 11.56 square inches.

"Height of sample, 3 inches.

"Ultimate crushing load, above 200,000 pounds."

(Note.—The strength of No. 2 was beyond the capacity of the machine, 200,000 pounds.)

As to the size of stone produced here it may be stated that one block prepared for the King Edward Hotel, Toronto, measured 9 feet by 4 feet by 16 inches.

The following represents a section, in descending order, in one of the quarries: Top, rotten or weathered bed 20 inches; thin layer; 30 inch bed, succeeded by beds having the following thicknesses, in inches: 21, 16, 14, 4, 3, 12, 12, 12, two thin layers, 14, 2 1-2, 20. The top layers are fossiliferous and brittle and are not used for cut stone. They, however, make the best lime.

Analyses

	1.	2.	3.
Lime	53.42	52.42	34.28
Magnesia	.72	.85	16.23
Carbon dioxide	42.68	42.00	44.70
Ferric oxide	.62	.22	.54
Alumina		.41	.72
Sulphur trioxide	.17	.30	.....
Alkalies	.05	.....	.....
Silica	.....	.....	.....
Insoluble residue	2.78	1.38	2.80
Loss on ignition	.....	1.78	.....
Water	.72	.....	.06
Sulphuric acid	.....	....	.44
	101.16	99.36	99.79

1.—Sample taken from 30-inch bed.

2.—Sample taken from brittle or rotten bed, 20 inches

3.—Sample taken from yellow bed, which has a thickness of 24 inches in one of the quarries. This is a good cutting stone, and letters well. The date stone, mentioned above, was taken from this layer.

Oxford

Quotations describing the limestone beds of Oxford county are made as follows from Reports of the Geological Survey and Bureau of Mines:

"An outcrop of the Corniferous limestone occurs near Woodstock, nearly on the axis of the main east and west anticlinal of the peninsula. To the north of this exposure, the western boundary of the formation is traced by the abundant fossils, which are found loose on the surface, in Wallace and Elma." (173)

"In Dereham, where only clay and sand overlie the Corniferous limestone, natural springs are found, yielding small quantities of oil; but neither the wells sunk in the clays of these regions, nor the borings into the limestones beneath, have as yet furnished any large amount of petroleum. Small portions of it are, however, still escaping at these points; which are on the lines of anticlinal fold and fracture, and are thus the natural localities both for the accumulation and the discharge of the petroleum contained in the subjacent upraised strata. . . . Near Tilsonburg, in Dereham, two wells were sunk in 1861. In one of these, after passing through thirty feet of clay, a boring of ninety-six feet was made in the Corniferous limestone. A fissure yielding petroleum was met with at twenty-five feet in the rock, and another at thirty-eight feet, which discharged small quantities of oil, with abundance of water and of gas at intervals. Some oil was also obtained beneath the clay, at the surface of the rock." (174)

"Masses of crystalline travertine [calcareous tufa] occur in fissures in the gypsiferous rocks at Oneida and elsewhere. Recent deposits of a similar nature, from calcareous springs, are abundant in many parts of western Canada, as at Dundas, Niagara, Woodstock and near Toronto. These travertines are sometimes solid and crystalline, like alabaster; and at others porous and tufaceous. They often enclose or incrust mosses, leaves and branches of trees" (175).

"Westward from Paris rock is next exposed at the Grand Trunk railway bridge at Woodstock. This outcrop resembles the cherty coralline limestone of the Corniferous as already described: it contains beautifully preserved examples of Favosites hemispherica as well as F. polymorpha (Billings), numerous Diphyphyllidae and Cyathophyllidae and Bryozoa. . .

(173) G. S. C., 1863, p. 371.

(174) Ibid, p. 787.

(175) Ibid, p. 455.

"Below this are about eight feet of thin-bedded blue fossiliferous limestone more or less cherty and bituminous throughout. . . .

"More of the above corals in fewer numbers and very numerous impressions of Bryozoa, particularly the Fenestellidae. The substance of those forms is unfortunately entirely gone and their only remains are the impressions on the flinty nodules.

Quarries

"Occasional exposures are seen in the valley of the Thames towards Beachville, where a number of quarries are operated on a rock of decidedly different general appearance from that at Woodstock. East of the village and north of the river a quarry has been opened, the surface layers of which are somewhat coralline, while the underlying rock is of a whitish color and carries bitumen. Across the river an extensive quarry shows this white layer with fucoids, Conocardium trigonale and numerous Athyris spiriferoides, with a less abundance of Zaphrentis prolifica. This white rock gives an excellent analysis as below:

	Per cent.
Water...	0.20
Silica...	0.13
Alumina...	trace.
Ferrous oxide	0.22
Calcium oxide...	53.71
Magnesium oxide...	trace
Sulphur trioxide...	0.35
Ignition loss...	43.92

"Three feet below this bed are a few feet of friable rock, followed by eight feet of thick-bedded (10 to 12 inches) limestone suitable for building purposes. Traces of petroleum are found in the corals and other porous parts of these beds. Below the village Mr. Jas. Bremner is carrying on extensive quarrying operations on beds which are higher (?) than the above. The quarries are not opened to any depth as, at about seven feet, a water-bearing stratum is cut which renders operations below this level more difficult. The stone being quarried is more massive than at the upper quarries and shows less petroleum and fewer fossils. This rock also makes a good lime, of particular value for chemical purposes owing to its freedom from magnesia.

"Assay of limestone from the Bremner quarries·

	Per cent.
Water......	0.55
Silica...	0.46
Alumina...	7.42
Ferric oxide...	1.50
Calcium oxide...	49.97
Magnesium oxide.	trace.

"About twenty-five men are employed in the various quarries at Beachville.

"Returning to Paris, and continuing the section northward we find surrounding Paris rolling hills of glacial detritus bearing isolated boulders of limestone (sometimes of considerable size) which are collected and burned to lime at various small kilns" (176)

Parry Sound District

Silurian strata are almost absent from the territory embraced in this district.

The limestone occurrences noted in the district are thus described:

"A group of islands situated about Georgian Bay, between Parry Sound and Franklin Inlet, and designated on Bayfield's chart as the Limestone Islands, very probably belongs to the series of rocks [Trenton group] under description" (177). I am told these islands possess no good harbor, and stone can only be transported from them with difficulty.

The following analysis of a sample of the Cambro-Silurian rock on the Limestone islands was made by a chemist in the United States for Mr. J. B. Miller, of Parry Sound:

	Per cent.
Calcium carbonate...	94.48
Magnesium carbonate	4.03
Alumina and ferric oxide..... .	0.52
Silica.....	0.76
Total...	99.79

This is equivalent to 52.91 per cent. of lime and 1.92 of magnesia.

Crystalline Limestones

"The crystalline limestones of the above region [between Georgian bay and Lake Nipissing] belong to at least three distinct bands, and it is probable that some of the exposures belong to a fourth, and others, possibly to a fifth band. With the exception of one locality, mentioned by Mr. Murray, more than 20 years ago, these limestones have not hitherto been noticed in any of the reports of the Survey, and their existence does not yet appear to be generally known by the inhabitants of the district itself, although for many reasons they are of much importance in relation to the settlement of the country. I shall now give the principal facts ascertained in regard to each of these bands during the short time at my disposal near the end of the season. The greater part of this region is still in a state of wilderness, and difficult to explore for geological details but towards Parry Sound itself it is becoming settled, and the roads which are being made in that vicinity gave us facilities which did not exist a few years ago.

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(176) B.M., Vol. XII., pp. 148-49.

(177) G.S.C., 1863, p. 193.

Burton Band

"The most western band of limestone of which I could get any information is reported to be well developed in the vicinity of Wa-wash-kaise (Little Deer) Lake, in the townships of Burton and McKenzie, and Ka-wa-shaig-amog (Clear Water) Lake, the position of which is not yet definitely located, but which appears to be near the northeast corner of Wilson. On Iron Island, in Lake Nipissing itself, Mr. Murray has described a crystalline limestone of Laurentian age which would lie in the course of the northward continuation of the band under consideration. About a quarter of a mile west of the southern expansion of Lake Wa-wash-kaise, the limestone of this band is said to come out in great force around a small lake in the eastern part of the township of Burton, from which circumstance I propose to give the band this name. It is stated to be nearly white in this locality, and to be worn into numerous caves. An exposure of crystalline limestone was reported to exist on the southern part of Shibaishkong Island, a few miles northwest of Parry Sound, and if this be a fact it may represent a southward continuation of the Burton band.

Parry Sound Band

"The band of crystalline limestone, on which the most exposures were found was traced from the southwest corner of the township of McDougall, near Parry Sound village, in a general bearing of N. 14 degrees E (ast.) for a distance of about forty miles, or into the township of Ferrie. The courses of the other Laurentian limestone bands of this region appear to be nearly parallel to this, which, I may mention, is also the general bearing of many of the similar bands which have been traced out by Sir Wm. Logan, in the country north of the Ottawa. The band under consideration, which I propose to call the Parry Sound band, must have a thickness of upwards of one hundred feet in many places. It consists, for the most part, of a very pure, coarsely crystalline limestone, which is usually white or very light grey, but is often tinged pink, green or yellow. On burning it yields an excellent lime. Among the minerals which I found associated with it were graphite and serpentine; the former as scales, disseminated through the mass, and on Manitouwabin Lake occurring in lumps of two or three inches in diameter; and the latter in grains and masses of an inch or two in diameter, on lot 32, concession A, Hagerman, at the east end of Lorimer Lake. Along with the serpentinous portion of the limestone at this locality there is a fine-grained and semi-crystalline rock, having, on fresh fracture, very much the appearance of a dolomite, but which Dr. Harrington finds, on examination, to consist of fine grains of quartz in a matrix of lime feldspar. This rock contains spots a few inches in diameter, stained to a beautiful purple tint by some compound of iron. Its position appeared to be near the western limit of the band, which is flanked on this side by gneiss, composed principally of quartz and lime feldspar. The limestone near the junction of the gneiss contains crystals of pyroxene and specimens of yellow mica, having the laminae arranged in a radiating form, or at right angles to the greater diameter of the mass. About the line between Lots 33 and 34, of the Northern Road in this vicinity a natural culvert, excavated in the limestone, passes under the road, and conveys a small stream which runs into the head of Lorimer Lake. The rock is here coarsely crystalline and nearly white, and does not crumble under the influence of the weather.

"On Lot 28, Concession 1, McDougall, about one mile east of Parry Sound village, where this band is quarried for lime-burning, it is very much reduced in thickness, and appears to be pinched out entirely a short distance to the northward. At the lime kiln it dips westward at a high angle, and consists of 12 feet of pure friable light pink and green, coarsely crystalline limestone, underlaid by twenty or thirty feet of similar limestone, interstratified with gneissic beds, and holding pebbles, and concretions. The latter appear to be made up principally of pyroxene, while the pebbles, which, are partly rounded and partly angular, consist of quartz with layers of crystalline hornblende. The largest pebble observed was about a foot in diameter, and most of them were under three inches.

"The rock which is here immediately associated with the limestone is a remarkable looking diorite, consisting of a white ground, thickly mottled with patches of dark green or blackish hornblende, having their longer diameter arranged parallel to the general bedding. This appears to be the rock which Mr. Vennor has described in the Hasting, Lanark and Renfrew region under the name of "blotched diorite." I found the same rock along the face of the hill on the north side of the brook, at the head of Partridge Inlet, which runs parallel to Long Inlet, at a distance of two or three miles south of it, both inlets being between the two northern mouths of the Muskoka River. I should not be surprised if it should be found that it forms the western flank of a band of limestone concealed in the valley of the brook.

"Crystalline limestone is said to occur at the head of the bay, about one mile west of the Indian village on the south side of Parry Island, which would be the most southern known exposure of the Parry Sound band. It is reported as occurring next on Lot 30, Concession XI. of Foley. The lime kiln above mentioned is a mile further to the northward. The next locality at which it is seen is said to be on the northern part of Lot 22, Concession I, of McDougall. It is well exposed on Lot 18, Concession II., of the same township, on a small pennisula at the east end of Mill Lake, where it consists of about sixty feet of creamy-white and light-pinkish coarsely crystalline limestone, with some included lenticular bands and smaller masses of hornblende. The dip is eastward, at an angle of 35 to 40 degrees. It next appears at the edge of the water of this lake, under a cliff on Lot 18, Concession III., and again forming the surface of a hill on Lot 17, Concession III., and dipping eastward at an angle of 60 to 70 degrees. Here it is full of pebbles and concretions, like those at the lime kiln, and it is underlaid by the mottled diorite above described. The latter rock is cut by veins of coarse granite, holding masses, a few inches in diameter, of black magnetic iron ore, which contains traces of manganese and titanium.

"The coarsely crystalline limestone of this band is largely exposed about the outlet and eastern extremity of Manitouwabin Lake, in Concessions VI., VII. and VIII., McKellar. Between this lake and the localities which have been described about the eastern extremity of Lorimer Lake, it is said to occur on Lot 19, Concession I, Hagerman, and beyond the latter lake, about Lots 43 and 44, Concessions A and B, on the Northern Road in the same township. Mr. D. F. McDonald of Parry Sound, to whom I am indebted for many useful facts in reference to the Parry Sound district, informed me that a coarse, whitish, crystalline limestone, which would be on the run of this band, is well developed on Lot 60, Concession B, and Lots 59 and 60, Concession A, in Hagerman, and I have been assured that a similar limestone is found on Lot 35, Concession XI., Croft. This brings us close to Maple Island on the Maganatawan River, in the southeastern part of McKenzie, from which Mr. Murray traced this band for three miles to the northward. He describes it as dipping eastward at a high angle, and as holding graphite, yellow mica and iron pyrites. The thickness is not stated, but, according to his accompanying plan, it would be at least 300 feet. Further on, the limestone occurs on the Northern Road, about the centre of the Township of Ferrie, and at the intersection of this road with Deer River. Beyond this, crystalline, whitish limestones, in which caverns are formed, are known to occur abundantly in the rear of Ferrie and in the unsurveyed township to the north of it, and also on Lake Minisegog; but it is uncertain whether these represent a continuation of the Parry Sound band or not. It is possible that the band, which appears to run in the same course from the eastern part of the township of Pringle to the south Bay of Lake Nipissing, is a continuation of the band under consideration; although it is equally probable that it belongs to the one to be next described.

Nipissing Road Band

"A band of crystalline limestone is traceable by numerous exposures on and near the Nipissing Road, from the township of Chapman all the way to South Bay, on Lake Nipissing, a distance of about thirty miles, the bearing of its general course being about N. 6 degrees E. (ast). I propose to call this the Nipissing Road band. Its whole width was not seen at any of the exposures which came under my notice, but it is, probably, not less than one hundred feet. In general character it is a light-grey or whitish, moderately coarsely crystalline limestone. It crops out at the following localities (stated in order from south to north), which are given partly from my own observation and partly from information which appeared reliable :

"Lot 24, Concession IX., township of Chapman, on the Distress River. Lots 110, 112, 114 and 120, Concession B, in the same township. Opposite the ends of Lots 126 and 129, Concession B, township of Lount. Lots 137 to 142, Concessions A and B, in Lount. On the road between Concessions VI. and VII., on Lot 6, Pringle. Lot 202, Road Range, township of Nipissing, near Muckwabi Lake. About Lot 215, Road Range A, Nipissing. About the western corner of Lot 218, Road Range B, Nipissing. On the peninsula between Namannitigong River and South Bay, Lake Nipissing, opposite "the landing," or the termination of the Nipissing Road. Similar limestone is said to occur on one of the Maniton Islands in the eastern part of Lake Nipissing, which lie in the continuation of the strike of this band to the northward.

"Southward this band may, perhaps, be represented by an exposure of crystalline limestone, said to occur at Goff's Mill, in the Township of Foley; and it is not impossible that the limestones of Robert's Bay (about to be described) may belong to the same band." (178)

"Among the most interesting rocks at Parry Sound are the crystalline limestones, which were studied somewhat carefully for a few days in the hope that they would provide a clue to the stratigraphical arrangement of the rocks of the region. A general account of the limestone bands of the region has been given by Dr. Bell.

"It was thought that if they were regularly interbedded with the schists the general relations of the schistose rocks might be made out by following the easily-recognized band of limestone. In general these limestones are white, gray or flesh-colored, coarsely crystalline, sometimes pure, but often containing darker grains of various silicates, and usually also fragments of adjoining schists, twisted and curled in an extraordinary way, as if the limestone had torn them off like an eruptive.

"The limestones near Parry Harbor were visited under the guidance of Mr. Adair, who observes such things carefully, and had already studied their distribution. Near Parry Harbor there are apparently two parallel bands of limestone, one with a strike of 53 degrees to 60 degrees and a dip of 25 degrees to the southeast, and a quarter of a mile southwest of this another band with a strike of 65 degrees or 70 degrees and a very gentle dip to the northwest. The direction, as well as the angle of dip is variable, and no outcrop can be followed more than a few hundred yards, though a succession of outcrops following the same general direction can be recognized. The thickness, too, is very irregular, being sometimes more than a hundred feet, and then rapidly thinning out till the band is lost among other rocks. There is no distinct stratification, and we may suppose that any traces of bedding have been obliterated by the process of crystallization, or by the squeezing to which they have evidently been subjected. As limestone is the softest rock of the region, it has been forced to adapt itself to the forms of the other rock masses. The accompanying schistose rock, gray, fine-grained gneiss or hornblende schist, is always much contorted and crumpled, and the proximity of the limestone may be recognized in this way, as noticed by Mr. Adair. The various outcrops of limestone near the town, if continuous, would make one or two bands a mile and a half long, probably extending at least four miles to the northeast, since limestone occurs again on the shore and on an island of Mill lake. Whether it continues on in the same direction is uncertain, but several bands will be noted later suggesting this. A small outcrop of limestone is found also at Depot Harbor, on Parry Island, four miles west of Parry Harbor." (179)

Peel

Exposures of strata of the Medina, Clinton and Niagara formations are found in this county. The following quotations are the only descriptions I have met with concerning the limestones:

"Two of the main indentations [in the escarpment] are on the Credit in Caledon" (180).

"The river Credit, in Caledon, is flanked on both sides by the cliffs of the Niagara limestone, in some places a hundred feet high; these in ascending the valley meet on the ninth lot of the fourth range of the township near Bellefontaine, and from a crescent-shaped precipice, over which the river falls in a cascade" (181).

"Prof. Chapman notes the occurrence of a very large block of Black River limestone in Albion, on the highest part of the Oak Ridge" (182).

Perth

The following quotations show the distribution of the Corniferous in this county. There are now important quarries at St. Marys, where very pure lime is produced. The stone is pure enough to use in beet sugar manufacture.

"An outcrop of the Corniferous limestone occurs near Woodstock, nearly on the axis of the main east and west anticlinal of the peninsula. To the north of this exposure, the western boundary of the formation is traced by the abundant fossils, which are found loose on the surface, in Wallace and Elma" (183).

"In the south-western area, which includes the region between the lakes Erie and St. Clair, the Corniferous limestones appear to become somewhat lighter in color, and more granular in texture than they are to the east. In this respect they approach in character to the rocks of the same formation in Ohio and others of the western States of the American Union. A section of about twelve feet of the formation is displayed on the banks of the north branch of the Thames at the village of St. Marys between the sixteenth and eighteenth ranges of Blanshard. The rock is exposed for about a mile and a half above, and for the same distance below the bridge, which here crosses the river. Its color is a light drab, occasionally weathering to a greenish tinge; it is very bituminous, and holds numerous fossils" (184).

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(178) G.S.C., 1876-77, pp. 202-207.

(179) B.M., Vol. IX., p. 166.

(180) G.S.C., 1863, p. 315.

(181) Ibid, pp. 327-8.

(182) Ibid, p. 895.

(184) Ibid, p. 371.

Borings at Stratford

"Continuing northward from Ayr, via Dundee, no exposures were seen, the country being rather uneven with light stony land of morainic origin. At about the point where the road from Dundee joins the main line to Hamburg the character of the country changes, the rough morainic deposits giving place to more level clay soil, which continues as far north as the section was carried, that is to Stratford and St. Marys. Some years ago a well was sunk at Stratford in the hope of obtaining gas; the following record was kept, which unfortunately is of doubtful interpretation: (185)

	Feet.
Drift	143
Limestone	90
White flint	117
Limestone	38
Flint	58
Limestone	100
Slate	40
Limestone	716
Medina	368
Hudson River and Utica	676
Trenton	40
Total	2,386"

Quarries

"The heavy deposit of drift reaching, as above noted, a depth of 143 feet at Stratford, is cut by the Thames at St. Marys, exposing the underlying limestones. The first outcrop of rock is seen about three miles east of St. Marys, where a tributary stream has eaten through the drift. A small quarry has been opened and about ten feet of thin-bedded, jointed, whitish-gray limestone exposed. The fossils are very poorly preserved; among them were noted Athyris spiriferoides and Spirifer gregaria.

"Lying north and east of the town of St. Marys, and at some elevation above the river, are a series of whitish limestones very similar to those on the Stratford road, but containing even fewer fossils. The two beds are doubtless analogous and represent the highest members of the Corniferous as here exposed. The rock is being extensively quarried and burned by Mr. J. Sclater. An analysis follows:

	Per cent.
Water	00.14
Silica	2.32
Ferric oxide	0.88
Alumina	0.17
Calcium carbonate	94 24
Magnesium carbonate	2.10

"On the south side of the river, at a distance of about a half-mile, the so-called Horseshoe quarry is being opened. Here the rock dips perceptibly to the west, and is somewhat fractured by local folding. The upper bed is a thin limestone weathering red, and lined with shells of Chonetes hemispherica and other species of the same genus. In less abundance are found Spirifera gregaria. Below this bed friable siliceous limestones occur with Conocardium trigonale which seems to be more or less confined to this bed. On descending, more heavily-bedded rock is found in which, at a depth of four feet, specimens of the rare species Panenka grandis were obtained. Along the river south and west of the Horseshoe quarry extensive operations have been carried on for years. Apparently the above described Chonetes bed is about eight feet down at these quarries, being overlaid by a series of shaly friable rocks bearing Orthis (Rhipidomella) livia, Athyris clara, Athyrias maia, Lucina elliptica and other lamellibranchs. Two feet lower is the bed which, as at the upper quarry, is characterized by the presence of Panenka grandis. It consists of a heavy blue limestone overlaid immediately by a thin bed. The Panenka limestone gives on analysis the following result:

	Per cent.
Water	0.41
Insoluble residue	4.49
Alumina	0.47
Calcium carbonate	90.22
Magnesium carbonate	2.09

"Below the Panenka bed is found a stratum characterized by the nautiloids Gomphoceras eximium, Gyroceras sp., Nautilus sp. and by Aviculopecten princeps. A very distinct horizon is marked by an abundance of fucoids lying at a depth of about 14 feet, below which the rock is more heavily bedded, of a bluer color and decidedly less fossiliferous. Although a few corals such as Zaphrentis prolifica, Favosites hemispherica, etc., are met with at St. Marys, the general series is not comparable with the highly coralline rocks to the southward" (186).

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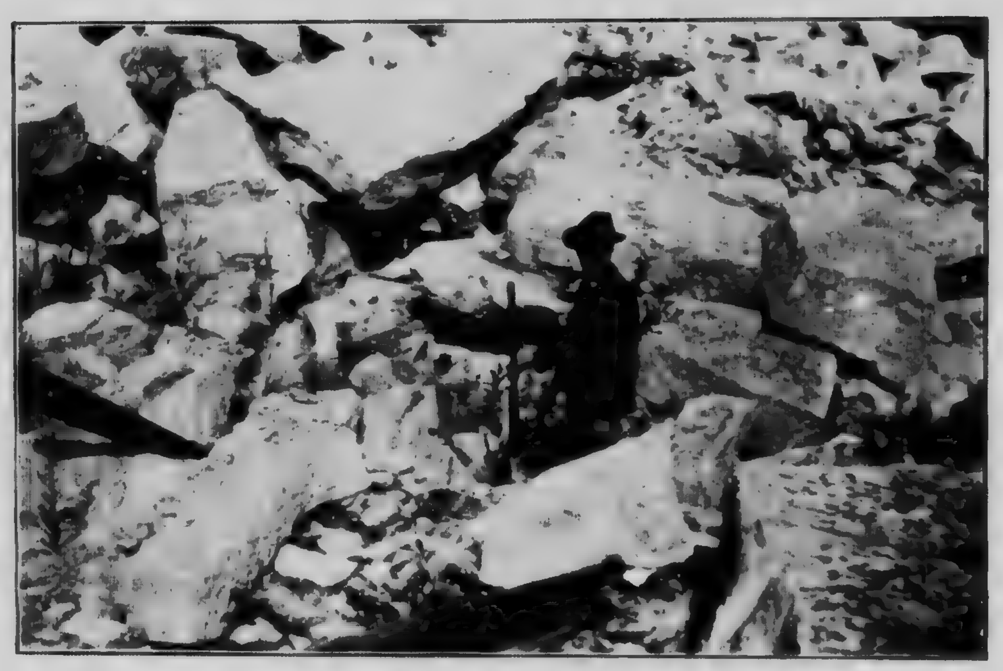
(184) G.S.C., 1863, pp. 377-8.
(185) B.M., Vol. XII., p. 150.
(186) Ibid, p. 151.



Limestone blasted out at Ryan and Haney's quarry, near Meldrum bay, Manitoulin island.

Beachville lime kilns. Oxford County.

Horseshoe Quarry, St. Mary's. Product used for building—rubble, sills and courses; and waste rock for road metal. Perth County.

Elliott's limestone quarry, St. Mary's. Product used for building, and waste rock for road metal. Perth County.

Grand Trunk Railway bridge, St. Marys; piers built of limestone. Perth County.

Sclater's lime kilns, St. Marys. Perth County

Sclater's quarry, St. Marys. For lime burning only. Ten feet of earth and gravel overlying limestone. Perth County.

The production from the Horseshoe quarry alone amounts to from 15 to 18 carloads (400 to 500 tons) a day, three-quarters of which is used in the crushed state for flux in the Hamilton blast furnaces, for road-metal in the cities and for the beet-sugar refineries. The remainder is used for building stone, principally as rubble and courses, some of it, however, being cut and dressed. The quarrying and crushing plant is quite elaborate, comprising two rock crushing houses, hoists, derricks, etc.

Physically this limestone, both here and in the adjacent quarries to the south and west, is tough and compact, and of a grayish drab color on freshly broken surfaces, which changes, after exposure, to a most pleasing bluish gray. The strata are well marked, easily separable and of various thicknesses, according to the bed to which they belong, ranging from 2 or 3 inches, suitable for flagging, to 2 feet for heavy dressed building blocks. The largest quarry in the district is amongst these older workings at the foot of the hill near the river and measures about 200 feet by 400 feet area by 20 feet depth, with a perfectly flat floor on the plane of stratification.

Peterborough

Palæozoic and crystalline limestones, together with marls, are found in various parts of the county. The Lakefield cement works use marl, and Portland cement has been used in some very important structures in the county, notably in the lift-lock near the town of Peterborough and in the building of the beet sugar factory. Palæozoic limestones, which are found in the southern part of the county, have been used extensively. Analyses are given below of samples from three or four localities. The insoluble matter in these is a little high for cases where a nearly pure calcium carbonate is required. The samples, however, represent surface material in which this matter is apt to run higher than in stone freshly broken in a quarry. Crystalline limestone is found in many localities in the northern part of the county.

"In their western run from Healy's Falls the escarpments [of the Trenton group] we have been following approach Stony Lake; the main one presenting an abrupt rocky cliff from two to three miles from the south margin of the lake, and the other, of small elevation, approaching the margin to within about a mile. After sweeping round a small sheet of water called White Lake, in the township of Dummer, the two escarpments partially unite, striking Salmon Trout or Clear Lake at about the fourth range of that township, keeping the south shore of the lake to its western extremity. The corresponding escarpment rises on the northwest side of Salmon Trout Lake, and then follows the sinuosities of the chain of lakes and the river up to Buckthorn Lake, keeping the south side at a distance seldom exceeding a quarter of a mile. It crosses Buckthorn Lake at the strait about two miles and a half above Buckthorn Falls; and then, again separating into two parts, the main one strikes nearly straight by Sandy and Pigeon Lakes to the head of Balsam Lake, the inferior escarpment keeping about a couple of miles to the northeast. In the general course westward from Belmont Lake, the rocks composing the lowest escarpment thin out and disappear before reaching the western end of Salmon Trout Lake. Here the base of the series is composed of very regular beds of buff colored limestone, bearing the lithological characteristics of the succeeding portion, while the upper tier of beds contains black chert and silicified corals of those species which peculiarly distinguish the Birdseye and Black River formation. The whole height of the escarpment, from this, seldom exceeds fifty feet.

"On the Otonabee the thick bedded coral-bearing stratum with chert . . . crops out on the twenty-second lot of the sixth range of Douro, where the river opens into a small lake called Kawchewahnook. Below this, assisted by the effect of a gentle undulation on the axis of which the river runs, there is a continued section of limestone and shales all the way to Peterborough, holdng many characteristic fossils of the Trenton formation. Between Peterborough, and Rice Lake, the Otonabee nowhere exhibits a rock section. .

"The limestone escarpment south of Burleigh Falls, in the township of Smith, is about eighty feet high. On the summit, thin beds of limestone and shale occur. . . . Except at the top, the rock is more or less covered by moss and small trees; but about twenty or thirty feet below strong beds of limestone occasionally come out in points, and probably represent the cherty beds of the Birdseye and Black River formation." (187)

"The lock on the Otonabee canal is constructed of massive beds of limestone, from the lower part of the Trenton group, which was quarried near Warsaw in Dummer; and good beds of similar stone are to be obtained in many other places in this region." (188)

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(187) G.S.C., 1863, pp. 188-9, 190.

Palæozoic Limestones

The composition of some of the Palæozoic limestones of Peterborough county is shown in the following table:

PALÆOZOIC LIMESTONES OF PETERBOROUGH COUNTY

	1	2	3	4	5	6	7	8	9
Insoluble residue	......	6.50	1.54	4.99	1.76	2.18	2.20	3.60	6.24
Silica	1.96	......	......	......	......	......	......	......	......
Ferric oxide	.61	.40	.30	.50	.38	.32	.50	.56	.54
Alumina	2.37	.54	.10	.25					.96
Lime	51.22	50.60	53.11	51.10	53.40	52.76	53.08	52.30	50.30
Magnesia	.70	.65	.65	.69	.57	.60	.60	.41	.97
Carbon dioxide	40.75	40.41	42.37	42.44	42.50	41.93	42.16	41.47	40.52
Loss	2.29	......	......	......	1.34	1.83	1.18	1.91	1.22
Sulphur trioxide	.21	.31	.10	.11	.13	......	.23	.39	.26
Alkalies	......	......	......	......	......	.18	......	......	......
Total	100.11	99.41	98.20	100.08	100.08	99.80	99.95	100.64	101.01

1.—Small quarry just east of Havelock. 2.—From Clear lake, near Burleigh falls. 3.—Bed just below top of cliff, lot 42 or 43, concession 16, Smith. 4.—About same locality as 3, but different bed. 5.—Topmost layer cliff near hotel. 6.—Quarry, lot 44, concession 16, Smith. 7.—Top of cliff, lot 45, concession 16, Smith. 8. Lots 1 and 2, just south of Lakefield boundary. 9.—Between 2nd and 3rd locks.

Prescott

Economic uses have been made of limestones of the Chazy, Black River and Trenton formations in this county. The following notes taken from reports of the Geological Survey describe briefly the distribution of these formations, and references are made to some of the more important quarries.

"The Chazy limestones also appear along the road in East Hawkesbury between ranges IV. and V., and are well seen on a road southwest from Barb postoffice between lots 22 and 23. They here contain certain fossils and have a low southerly dip. Similar rocks show along the road to St. Eugene.

"West of L'Orignal the country is largely clay-covered for several miles. About 3 miles from the village several rock outcrops appear along the south side of the river road and in these a number of quarries are located. Some of these are in rocks of Black River and Trenton age, and the presence of the fault which was noted on the road south of L'Orignal is recognized in the tilted attitude of some of the strata. Outcrops of Chazy shales overlain by limestones of the same formation however appear and these are highly fossiliferous. The rocks are nearly horizontal or with a low dip to the south, and on a road leading from the village of Alfred to L'Orignal, known as the L'Ange Gardien road, Black River and Trenton limestones appear with low undulations. . . .

"The Black River limestones can be well studied at . . Murray's quarry, about one and a half miles south of L'Orignal, and several others to the south of this in East Hawkesbury. The formation [Black River] is important as furnishing some of the best building stones of the Palæozoic series. . . .

"A large quarry in the upper portion of the formation [Black River] is found at the crossing of a road over the Riviere a la Graisse, on lot 15, range VII., Hawkesbury East. . . .

"The Trenton limestones are extensively developed throughout the townships of Cumberland, Clarence, Plantagenet, Alfred, Caledonia and Hawkesbury west and east. In the southern portion of most of these they are overlain conformably by the Utica shales which form the central part of the great Palæozoic basin. In the eastern part of the area the strata are affected in the same manner as those of Black River and Chazy age by the great Rigaud fault. They are well seen along the road from L'Orignal to Vankleek Hill, and southwest from the contact with the Black River formation at the fault near Murray's quarry they have a surface breadth till they are overlapped by the Utica of not far from 8 miles.

"West of L'Orignal they are well exposed along L'Ange Gardien road towards Alfred for about a mile, in low undulations. They occupy the upper part of the big escarpment south of Brown's wharf and thence are seen along the Nation river in the direction of Plantagenet village in large exposures, the rocks are filled with characteristic fossils of the formation, and the dip is to the south at angles of 3 to 5 degrees" (189).

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(188) G.S.C., 1863. p. 816.

"The limestones of the Chazy, Black river and Trenton formations have long been noted for the excellence of their material for building purposes, and large and valuable quarries exist in the areas occupied by these rocks. Among these may be mentioned the Ross quarry, in the township of East Hawkesbury, in limestone of Chazy age, and from which a very large amount of excellent stone was taken for construction work on the Grenville and Carillon canals. Near L'Orignal also quarries are found in the Black River and Trenton formations (Murray's), the stone from which has been used for the same purpose. Butler's quarry in the Chazy limestone about three miles west of L'Orignal, near the river road, and several others in the Black River or Trenton limestones of adjoining lots are well-known and the quality of the stone is excellent. These are in the western part of the township of Longueil" (190).

"Gray beds of the Chazy formation, thickly marked by small bivalve shells filled with white calc-spar, have been wrought to a small extent near L'Orignal, but the stone is not well fitted for a marble, inasmuch as the shells are readily detached from the rock." (191).

"About two miles from the mouth of the South Petite Nation, the Birdseye and Black River formation crosses the stream, dipping southward at an angle of four degrees. Trenton beds are seen resting on it, and they underlie the road up the valley for more than a mile, in which they appear to be quite horizontal. These rocks are seen in the same relation on the east side of the township, in an escarpment below the road, crossing the line between Plantagenet and Alfred, about two miles from the Ottawa. The escarpment and the road keep in the same relation for two miles and a half farther to the south-eastward, up the valley of the brook flowing into George Lake; but three miles farther east, on the second range of Alfred, the escarpment is south of the road, and on the summit there occurs a bare triangular surface of Trenton limestone of a mile and a half long. In the township of L'Orignal, the escarpment approaches nearer the Ottawa, being about a mile from it on the west side, and a mile and a half on the road, which runs back from the village. In the rear of Hamiltonville in West Hawkesbury, it is two and a half miles from the margin. Its position in East Hawkesbury is not so well ascertained, but the base of the series very probably reaches the boundary between the western and eastern divisions of the Province, in sweeping round the extremity of the trough north of the Rigaud anticlinal. On the south side of the trough, limestone beds are met with at McDonald's Mills, on the Riviere a la Graisse, in the fifteenth lot of the seventh range of East Hawkesbury. These are at the base of the Trenton, and very nearly in the strike of these beds, there is an exposure of Trenton limestone in the thirty-second lot of the ninth range of the Lochiel" (192)

"At about one mile and a half south of Vankleek Hill, there is a small quarry in fine gray, very brittle and bituminous Trenton limestone, with partings filled with bituminous matter and joints coated with white crystallized calcite. The beds here are somewhat folded" (193)

"Another Black River quarry is seen on the River à la Graisse, in the south-eastern portion of Hawkesbury East, where they have a dip to the south-west at an angle of about 10 degrees. They are here separated by a heavy fault from the Potsdam sandstone, about two miles west of the village of St. Anne de Prescott" (194).

Prince Edward

Trenton limestones underlie this peninsular county and crop out on its shores at points convenient for shipment. At the outlet of the lake of the Mountain, for example, in the shore of the bay near the entrance to Picton harbor, the perpendicular rock cliffs are upwards of 200 feet in height.

The writer has met with no detailed description of the outcrops of limestone in the county or around its shores, but it may be said that the chemical composition of the rock is pretty uniform in character, carrying a high percentage of calcium carbonate, when flint nodules are absent. Now that there is a growing demand for rock of this kind for use in various industries it would seem that the outcrops near the water's edge may be worked to furnish a supply of stone for use along the upper part of the lake.

The following analyses represent samples from Picton. The residue, insoluble in hydrochloric acid, in 1 was 5.42, and in 2 it was 2.42 per cent. The first sample is from Sullivan's quarry, and the second from the corporation quarry:

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(189) G.S.C., 1899, pp. 85-87 J.

(190) Ibid, p. 136 J.

(191) Ibid, 1863, p. 827.

(192) Ibid. p. 171.

(193) Ibid, 1896, p. 72 A.

(194) Ibid, 1899, p. 135 A

	1.	2.
Silica	4.40	2.00
Ferric oxide	1.73	.76
Alumina	.45	.24
Lime	51.08	53.46
Magnesia	.88	.71
Carbon dioxide	40.45	42.32
Loss	.20	.20
Sulphur trioxide	.07	.29
Alkalies	....	.18
	99.92	100.16

The limestones in the other parts of the county, when not containing nodules of chert or flint, have a similar composition.

Sullivan's quarry is near the Catholic cemetery. Its face has a height of 10 or 12 feet and extends along the cliff for some distance. The rock is dark colored, fossiliferous, and rather thin bedded, with shaly seams between the layers. The rock is used for foundations, the thickness of the layers not exceeding 5 or 6 inches. The corporation quarry has a face of 25 or 30 feet in height at the back of the quarry. The beds of limestone are only a few inches in thickness, and are interbedded with thin layers of shale or clayey material. It would be possible if such a mass of rocks were free from magnesia and other deleterious constituents, to use the whole mass in the manufacture of Portland cement, adding more or less clay to the mixture.

Rainy River District

Limestones are rare in this district. The crystalline limestone which is found at Steep Rock lake presents the most prominent outcrops. These have been described by a number of writers. (195) Samples taken from one of these outcrops by the present writer possessed the following percentage composition:

	1.	2.
Insoluble residue	.....	.63
Silica	26.46	.....
Alumina	2.10	.....
Ferric oxide	.....	.30
Ferrous oxide	5.94	.....
Lime	20.34	54.90
Magnesia	9.63	.61
Loss	.....	2.04
Carbonic acid	26.32	41.66
Sulphur trioxide	.....	.13
Alkalies	.....	traces
		100.27

1. The lime and magnesia here shown exist as carbonates. The insoluble silicious residue after treatment with hydrochloric acid is equal to 31 per cent. The lime and other bases were not determined in this, but the total silica in the rock, as shown above is 26.46. The loss on ignition was 30.08 per cent., which includes the carbonic acid, 26.32 per cent. (196)

2. In this analysis the percentage of lime is high. It represents a much purer limestone than does 1. Sample 2 is dark limestone, which is enclosed or surrounded by the lighter colored, which is represented by analysis 1. The darker appears to have been the original rock, which has been brecciated and partly dissolved. The lighter colored rock formed from the darker chiefly by solution and reprecipitation, contains fragments of the latter.

In the following notes taken from reports of the Geological Survey reference is made to the occurrence of boulders of Silurian limestone in the district. These are of economic importance as large lime-kilns often make use of "field" stone. Marl deposits also occur in the district, and may be made use of in the production of lime, and for other purposes.

"In the post-glacial formations of Rainy River, the clays, sands and limestone boulders are all of economic value. Some of the lower blue clay seen on the banks of the river appeared to be very pure and capable of being worked for pottery. Other clays would make good bricks. Much of the sand intercalated with the clays would be serviceable for building purposes, and some of that at the mouth of Rainy River would be good for glass making. The limestone boulders are occasionally burned for lime by the settlers." (197)

"In valleys tributary to Rainy Lake, such as the basin of the Seine River and that of the Turtle River, there are local deposits similar to those on Rainy River which may perhaps be regarded as having been formed in arms or bays of Lake Agassiz. These deposits appear to lack a feature which is very characteristic of the deposits along Rainy River, viz., the presence of pebbles of cream-colored or yellow Silurian limestones. The northern limit of the distribution of this limestone drift has been noted by Bigsby, Dawson and myself, and it appears to be coincident with the line that has been sketched as limiting the northern extension of the post-glacial formations. The limestone pebbles and boulders, while doubtless derived in the first instance from the Silurian rocks of the Red River basin, appear on the Lake of the Woods to come immediately from the post-glacial strata in which they are imbedded. Their glacial origin is attested by the very common and distinct striation observable upon them;

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(195) Am. Jour. Science, 1891, pp. 317-331, and B.M., Vol. XI., pp. 131-3.

(196) B.M., Vol XII., pp. 306-7.

(197) G.S.C., 1887-88, part I., p. 182 F.

which fact also attests that they have been very little water-worn since their escape from the foot of the glacier, the inference being that the clayey strata in which they are imbedded were derived largely from the same glaciers. With regard to other isolated patches of post-glacial formations, it is to be noted that those of any considerable extent that are known, such as that near Lake Wabigoon, appear to lie on the north side of the height of land, and may have been formed at a somewhat later stage of the recession of the ice barrier, after Lake Agassiz had shrunken to a fraction of its maximum size. On this assumption the lake in which the deposits around Wabigoon were deposited would have had the height of land for its southern barrier, and probably the ice for its northern. There are few facts, however, as yet to support such speculations, and they are only suggested by the analogies which the results of Mr. Upham's work naturally lead us to look for." (198)

"Between the Laurentians of the Ottawa Valley and of Western Ontario, there is one marked difference, the presence of a series of limestones in the former, and its comparative absence in the latter ; but the absence of a lithological member of a series, as limestone or quartzite, does not militate against the correlation of the members occurring in different districts, and future investigation may prove the Couchiching series to be the stratigraphical equivalent of the Upper Laurentian series of the east, to which as far as may be gathered from published descriptions of the latter, the mica schists would seem to bear a marked resemblance in stratigraphical relationship. But whatever conclusion may be eventually arrived at regarding the origin of Laurentian rocks, or whatever subdivisions of, or re-arrangement of certain members of this system future investigation may justify, the separate areas of granitic rocks referred to in this report present no individual characteristics sufficiently significant to justify the belief that any great difference exists between their respective ages, and the same theory of origin that applies to one applies to all." (199)

"At the narrow entrance to Echo bay [Shoal lake], a four-foot seam of crystalline limestone, containing some copper pyrites, was observed in the sericitic schist. This is not very pure, containing some quartz, etc, but may at some time be of value for lime" (200).

Renfrew

This county possesses important resources in crystalline limestones or marbles, Cambro-Silurian limestones, and marl deposits. The marble deposits in the vicinity of the towns of Arnprior and Renfrew have been described in several reports, published during the last half century. Quotations from some of these reports are given in the following notes. The only quarries of crystalline limestone now being worked in the Province for marble or decorative building stone are those of the town of Renfrew and one a few miles from Haley station, some distance to the westward. The town of Renfrew is also one of the largest producers of lime in eastern Ontario, the rock used being the crystalline limestone, which is quarried within the limits of the corporation. It will be seen from the analyses given below that this lime possesses a high degree of purity.

Crystalline Limestone.

"A marked feature in the formations in the vicinity of the Madawaska, in the area to the south of that river, is the great development of crystalline limestones. In character these differ somewhat from the limestone found in the Grenville district. They are often characterized by the presence of bluish and bluish-gray shades, and by a well-defined banding, which imparts a peculiar striped aspect to the rock over large areas. The limestone is also often highly dolomitic, and in places weathers to a peculiar ochreous brown. Instead of the usual association of grayish and reddish-gray gneiss found north of the Ottawa, the associated rocks are mostly schists, either hornblende, micaceous or chloritic. The characteristic mica-schists are beautifully exposed on the line of the Kingston & Pembroke Railway, between Lavant and Flower stations, as well as along certain portions of the Mississippi River, on the north side of Mud Lake, about a mile below Ardoch. They are also well seen on the south side of Marble Lake, in the township of Barrie. The hornblende rocks, however, have a much greater development, being often massive" (201).

"North of the Madawaska, in the townships of Griffith, Brougham and Bagot, while the surface of the country is often exceedingly rough and broken, great areas of crystalline limestone, often dolomitic, are seen. These calcareous masses occur, not only in the valleys but constituting large hills. In places the rock is highly charged with tremolite, and this character is also well seen in the limestones to the north of Calabogie Lake, as well as at certain places in the township of Darling, and in South Kinnaley. Great areas of these limestones, often well exposed, occur in McNab, Darling, Lanark and Ramsay" (202).

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(198) Ibid, pp. 175-6 F.

(199) G.S.C., 1890-91, part I, p. 37 G.

(200) B.M., Vol. V., p. 49.

(201) G.S.C., 1896, pp. 55-56 A.

"It is interesting to note the occurrence of unmistakable limestone conglomerates in the Laurentian crystalline rocks of the Grenville series in Renfrew county. These were seen at several widely-separated points, as in the township of Westmeath, along the Rocher Fendu channel of the Ottawa, in the townships of Bromley and Stafford, in Sebastopol, and along the Opeongo road. In these conglomerates, which rest upon the rusty gneiss, are pebbles of garnetiferous, hornblendic and reddish gneiss, quartzite and rusty gneiss, well rounded and water-worn. The grayish quartzose gneiss, in the lower part of the calcareous series, presents all the aspects of an altered quartzose sandstone, and the whole series at these places looks like a succession of altered sediments. . . .

"Very considerable areas of crystalline limestone occur throughout the counties of Renfrew and Pontiac, some of which constitute useful marbles. . . At Renfrew [town], extensive quarries exist, which furnish an excellent quality of stone, both for building and for burning. . . A new deposit of snow-white marble has been opened up on lot 19, concession 6, Ross, on the property of Mr. Chas. Bilson. This is a beautiful stone, highly crystalline, and yields large blocks for monumental or decorative work" (203).

Marble Quarries

Mr. Alexander McLean thus described his marble quarry at Renfrew to the Royal Commission on the Mineral Resources of Ontario :

"We have a marble quarry at Renfrew and one in the township of Templeton, Quebec. We have leased the Renfrew property, and we get from it what is commonly known as the Renfrew marble; it is a crystalline marble. We leased that about three years ago. Since we have had it we have taken considerable out. We do not work it steadily; we just take out the quantity that we require. We use it for monumental material, slabs, copings, window sills, trimmings, and for such purposes. It is an excellent stone, and takes a good polish. It is a degree harder than the ordinary limestone, and is not so liable to stain as the ordinary white marble" (204).

The Commissioners themselves give the following account of the marbles or crystalline limestones at Renfrew and Arnprior :

"The town of Renfrew is situated over a very wide band of crystalline limestones, which crops out at different points, but especially upon a lot in rear of the Roman Catholic church. This latter is well adapted for quarrying into large pieces of solid and massive stone, which is free from checks and dries, and stands working, sawing and trimming for marble purposes. The property is operated by the Canadian Granite Company of Ottawa, and the product is shipped to that city for manufacture. The marble is a crystalline limestone of grayish hue, slightly tinted in places with hornblendic crystals, and in other places small crystals of mica are visible. It is taken out by block and feather, and costs $2.25 per cord for labor. The largest blocks are nine feet long by two feet square, and about 25 per cent. is wasted in the quarrying. It stands the weather better than any stone except granite, and some granites will not stand as well. We saw one building which had been put up nearly forty years ago. No action from the weather was visible, except that the tint had become slightly darker where most exposed, and this change could only be seen upon careful observation.

"There is another wide band of crystalline limestone at Arnprior, upon which several openings have been made, and near which works have been erected for cutting and polishing. At the works the strata dip 30 degrees to the south-west, and the strike is north-east and south-west. This band is of a bluish tint with dark blue wavy lines, and yields marble of excellent appearance and quality. The plant of the mill consists of three sawing gangs, three turning and two polishing lathes, and a rubbing bed, all driven by a 25-horse-power engine. The marble is made chiefly into monuments, but it is also manufactured to a small extent into table tops and mantelpieces, and is used in public buildings for decoration" (205).

The Arnprior quarries are further described by Mr. A. R. McDonald as follows :

"I live at Arnprior, and am a member of the firm of R. McDonald & Son. I am engaged in the marble manufacturing and producing business. One of our quarries is at the corner of Russell and

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(202) G.S.C., 1896, p. 57 A.

(203) G.S.C., 1895, pp. 66-67 A.

(204) Roy. Com., 1890, p. 84.

(205) Ibid, p. 76.

Elgin streets in this town; the other is about a mile and a quarter distant, in an easterly direction, on a cove of the Ottawa river. The marble from that quarry is known as Ottawa valley marble, while the other is known as Arnprior marble. We have another quarry here at the mill, but it is the same as the Arnprior. We have three sawing gangs, five lathes, three turning lathes, two polishing lathes, a rubbing bed, and a 25 h.p. boiler and engine. I do not know the total value of the plant. This mill was formerly on the south side of the Madawaska, and was owned by Farquharson, McLaughlin & Hartney; they ran it for about four years. We acquired the property in the fall of 1878, and have been running it since. I cannot tell you what our output is. Our market is altogether in Ontario. It is used for monumental purposes, and to a small extent for ornamental purposes, such as table tops and mantlepieces. It has been used for a number of public buildings, among others, in the House of Commons at Ottawa. I suppose we make about $4,000 or $5,000 worth of monumental marble a year. The Arnprior marble has a dark blue ground with wavy veins, the Ottawa Valley marble has a gray ground with dark wavy veins. I do not know any other marble that will take as good a polish; it cannot be stained; it will not absorb moisture at all, and it stands exposure well. We have not been working this year, one reason being on account of the state of the market. When we are working we employ from fifteen to twenty-five men. The engineer gets $1.50 a day, quarrymen $1.25, polishers $1.25 to $1.50, stone cutters $1.25 to $2.50, and other men $1.20 to $1.25. One of the reasons that we find it difficult to compete with the American marble is that our stock is very hard and difficult to get out, and then it does not come out in the right shape. American mountain blue is a cheap marble. Southern Falls is a good marble; it is light in color, and I think it is as good as this; besides, it can be worked cheaper than ours. The Ottawa Granite Co. get marble at Renfrew, but they don't sell much of it as monumental marble; it is mostly the American that is sold for that purpose. The duty on marble is 35 per cent. sawed on four sides, 25 per cent. on two sides, and in the rough, 15 per cent. I am informed that the Americans sell marble here at $2 and $2.50, while they sell at $3.50 in their own country. They make a slaughter market of ours, and it is mostly inferior marble they sell here. That is the reason we are not running now. The marble dips about 30 degrees, and runs northeast and southwest. About a mile and a half from here we have a marble very like the Gouverneur marble; it is light gray with light brown streaks, and extends about five miles to the south and three miles to the west. There is no granite in this part of the country; it is all marble. Northwest it extends about twenty miles, and east of here about twelve or fifteen miles. In different places it varies in color and texture" (206).

The Renfrew limestones and marbles have frequent mention in the Reports of the Geological Survey, from which the following extracts are made:

"Ferguson's Quarry.—This quarry, on Lot 22, Range IV., of Ross, is in a fine gray crystalline limestone, striking N. and S., with an easterly underlie. In burning, it produces a somewhat granular lime, but makes a hard-setting mortar.

"The kiln has a capacity of only about 300 bushels, which amount is produced about six times a year.

"This stone, on account of its fine texture, might be applicable for building purposes, or would also, I have no doubt, constitute a handsome marble.

"On Lot 7, Range IX., bands of a coarse crystalline white dolomite occur, which is said to burn to a good lime.

"A similar band occurs on Lot 23, Range IV., slightly coarser in texture, and when struck with a hammer shows a momentary red phosphorescent glow.

"Either of these dolomites would be susceptible of a high polish. But, as the outcrop indicates a very limited thickness, it is doubtful whether it could be worked with profit.

"On Lot 20, Range IX., of Bathurst fine terminated crystals of pyroxene, hornblende, orthoclase, scapolite, apatite and titanite occur in a calcareous vein, cutting granite.

"On Lot 23, Range IV., of Ross a band of tremolitic dolomite, traceable across several lots, affords in many places long translucent rhomboidal columns and interlacing blades of tremolite, the former often one foot long and one inch across.

"Small specks of apatite were noticed in a disintegrating limestone, that is occasionally mixed with dolomite" (207).

Palaeozoic Limestones

"A band of crystalline dolomitic limestone, with mica-chlorite and hornblende-schists, also cut by diorites, crosses the river in the vicinity of Arnprior, and has a breadth westward of several miles. . . Portions of their area are also overlaid by thin beds of Calciferous limestones, on the north shore opposite Arnprior and Braeside. Above this, to Portage du Fort, the rock where exposed is mostly Laurentian limestone, forming a series of synclinals, underlaid by rusty gneiss, the whole cut by frequent intrusions of syenite and diorite. . . At the Portage du Fort village, there is a great development of the crystalline series, the intrusions being particularly well seen, and their action upon the limestone being marked by their alteration of this rock into marble. From certain beds of this locality the marbles employed in the interior of the Houses of Parliament in Ottawa were obtained" (208).

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(206) Roy. Co., 1890, p. 82.

(207) G.S.C., 1882-3-4, p. 15 I.

"The Roche Fendue channel, on the south side of Calumet Island, is very rocky, broken by numerous heavy rapids and chutes. The rocks are limestone, underlaid by rusty gray gneiss, but the syenitic and dioritic intrusions are frequent and masses of the limestone are often caught in the intrusive rocks. The rock on the north side of the Ottawa, between Bryson and the foot of Allumette island, is mostly syenite. Occasionally small bands of limestone and gneiss are seen, but their area is small as compared with the syenite portion, and they are much broken up.

"Allumette Island, and the south side of the river opposite, are occupied largely by Chazy rocks. The typical Black River occurs at Paquette Rapids, many of the beds being filled with fossils of that formation, which are beautifully preserved. Much of the island however is low, and large areas of sand and bog occur inland. The northwest portion is mostly syenite. In the north or Culbute Channel, a heavy rapid is overcome by a lock, while in the south or Pembroke Channel, the navigation is interrupted by the Paquette and Allumette Rapids, the latter about three miles below the town of Pembroke. These however can be traversed by steamboats at certain stages of the water. . . .

"The only trace of limestone seen in this portion of the river was a thin crushed band above the narrows about one mile below the mouth of the Swego River, some thirty-five miles above Pembroke.

"Some interesting points of structure were observed at various places. While it is very evident that the syenites or granites as a whole in this section are intrusive in the crystalline limestone, some portions of them are of comparatively recent date. Thus about six miles above the Coulonge, they have apparently disturbed the usually horizontal beds of Calciferous and Chazy, the latter in one place being pushed up along the contact to angles of 36 and 40 degrees." (209).

"Inland, to the south, the Chazy and lower part of the Trenton formation have a considerable development in the valley of the Bonnechere at Eganville, whence they extend eastward to Douglas village. The flat-lying limestones occur for some distance on both sides of that river. Another outlier extends from the east side of Lake Dove eastward to Mink Lake, and thence spreads over the flat area between Douglas and Cobden; while yet another considerable area occurs on the lower west half of Muskrat Lake, which is discharged by the Muskrat River at Pembroke. Along this stream the Chazy beds also show, capped in Stafford township by highly fossiliferous strata of Black River age. A small outcrop of Chazy is again seen in a cutting on the Ottawa and Parry Sound railway about three miles west of Killaloe station, while on Clear Lake, to the south the Trenton and Utica beds are exposed at the southwest corner." (210)

"A new outlier of the Black River was discovered in the low tract to the west of Clear lake, in the township of Sebastopol, and the Palæozoic formations seen around the northwest corner of the lake, comprising the Trenton and Utica, appear to extend westward and to underlie a depression, which continues as far as the road from Brudenell Corners to Killaloe. From the character of the drift and soil on the road leading up the mountain from Castile post office, it is very probable that the Utica outlier of the south side of Clear lake also extends in this direction for several miles, overlying the Trenton and Black river formations. It is probable from this Black River outlier, west of Clear lake, that the large masses observed along the north slope as well as along the top of the mountain, on the Opeongo road have been derived. The direction of the ice movement in this district was a few degrees west of south." (211)

Sand Point Quarries

There are two quarries in the Palæozoic limestone at Sand Point village, and one or more within a distance of a mile or two. At the time of the writer's visit stone was being shipped from one of the village quarries to North Bay, which was to be used in the building of the round houses and other structures on the Temiskaming and Northern Ontario Railway. This quarry, which lies east of the station, has a face of about 18 feet, and little earth on top of the rock. The other quarry has a face of over 20 feet, but the rock is here covered by about 15 feet of sand. The stone in one house which is said to be over 50 years old is in a good state of preservation. It retains its color well, not becoming lighter with age like the stone of Kingston and elsewhere. Many door and window sills, having a thickness of 15, 16 or 18 inches, have been taken from these quarries.

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(208) G.S.C., 1894, p. 59 A.

(209) G.S.C., 1894, pp. 60-61 A.

(210) Ibid, 1895, p. 65 A.

(211) Ibid, Sum. Rep., 1897, p. 61.

There is a small quarry at Braeside from which stone for building and lime burning is taken. The lime is said to be strong and quick-setting.

Following are analyses of samples of the stone taken from these Sand Point quarries:

—	1	2	3	4
Insoluble residue	......	......	.....	[illegible]
Silica	4.20	4.11	2.54	
Ferric oxide	.72	.82	.92	1.03
Alumina	1.40	2.04	.74	.99
Lime	46.02	46.24	50.80	29.98
Magnesia	4.37	4.45	2.15	19.03
Carbon dioxide	40.60	41.00	42.00	44.30
Loss	.82	.22	.15	. .
Sulphur trioxide	.36	.66	.36	.10
Alkalies	......	.25	. . .	
Total	98.49	99.82	99.66	100.30

1. Quarry at road side, just east of Sand Point station; 2, quarry near hotel, Sand Point station; 3, Barnet's small quarry, Braeside; 4, small quarry across road from Eckford's house, just east of Arnprior.

"Pembroke, O., lot 12, range 1.—The Chazy formation at this locality affords good limestone for building purposes, in beds from three to eighteen inches thick. An analysis of a specimen gave:

Carbonate of lime	83.96
Carbonate of magnesia	9.29
Carbonate of iron	0.69
Insoluble	6.06
	100.00

"The stone is light brownish-grey in color, compact and breaks with a conchoidal fracture

"McNab, Ontario.—The Calciferous formation in many localities affords material which answers for building purposes, and appears to be very durable, though often difficult to dress. In some cases the rock is limestone, but it seems to pass by insensible gradations into dolomite, the prevailing rock of the formation. A specimen of the limestone from near Arnprior, on the 11th lot of the third range of McNab, was found to contain:

Carbonate of lime	81.78
Carbonate of magnesia	13.68

"It is compact and dark brownish-grey when fractured, although when tool-dressed it has a rather bluish-grey tint. When polished it shows sections of fossils and presents a mottled surface of dark-grey, with patches of light-grey and yellowish-brown

"Another specimen from the same set of beds, but considerably lower down in the formation, was light brownish-grey in color, and dotted with occasional crystals of white calcite. When polished it presented a mottled appearance, like the limestone just described, the colors, however, being much paler. As shown by the following determination, it is a dolomite:

Carbonate of lime	53.00
Carbonate of magnesia	43.88

The specimen came from an old quarry on the 9th lot of the 14th range of McNab." (212)

The Lime Industry

The lime industry at the town of Renfrew is larger than that of any other place in the eastern part of the Province. The lime is shipped south to lake Ontario, and for a considerable distance east and west. The quarries, which are referred to on another page, are in crystalline limestone. There are three draw kilns 5 feet in diameter and 20 feet high. They each have a capacity of 150 bushels of lime in 24 hours. Lime is withdrawn from the kilns 36 hours after the first starting afresh, and thereafter every 12 hours. Lime sold in Renfrew during the past summer at 25 cents a bushel.

The limestone from these kilns works best if allowed to slack for some time before using. This prevents the danger of chipping in plaster.

Foundation stone (crystalline limestone), sold at $5.00 a cord, delivered, in the town of Renfrew during the past summer. It may also be added that bricks were $7.00 a thousand, and sand, for building, 40 cents a cubic yard.

Of the following two analyses from Jamieson's quarries, No. 1 was made by J. T. Donald, and No. 2 by A. G. Burrows.

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(212) G.S.C., 1876-77, p. 486.

	No. 1.
Calcium carbonate.....	87.32
Magnesium carbonate....	7.87
Ferric oxide and alumina..	0.92
Silica and insoluble....	2.04
Volatile matter........	1.85
Total.....	100.00

	No. 2.
Lime.....	49.23
Magnesia...	3.69
Alkalies....	0.63
Alumina....	trace
Ferric oxide..........	0.76
Silica.....	1.39
Sulphuric acid...	0.26
Carbon dioxide....	41.54
Moisture.....	0.28
Organic and volatile matter.	1.89
Total	99.67

Samples for analysis were also taken from two or three other quarries (in crystalline limestone) in the vicinity of the town of Renfrew. Considerable stone from Scott's quarry has been used for foundations and other structures. Large blocks or columns have been taken out of Leitch's quarry. One of these lying on the ground had a length of 12 feet, and a thickness of between eighteen inches and two feet. From a second quarry of Jamieson's, near Leitch's, stone has been shipped to Sudbury for use as a flux.

A quarry, known as Quinn's, about four miles from Haley's station, was visited. It is in the east half of lot 19 in the sixth concession of the township of Ross. The rock is white crystalline limestone, and has been used in the manufacture of tombstones, window sills, building stone and for other purposes. The stone has been shipped to Ottawa, Montreal and Sault Ste. Marie. At the latter place it is used as a "trimming" in the new public buildings, the fire hall and library, and gives a good effect with brick. A stone to be used as a sill in a bank at Coulonge, had been gotten out shortly before my visit. It had a length of nine feet, and in cross section was seven by five inches.

Following are analyses of crystalline limestones from Renfrew county:

1, Arnprior, small island near bridge; 2, sample from opening for road material at McLaughlin's mill, Arnprior; 3, Eckford's larger quarry, east of Arnprior; 4 represents a sample from a smaller quarry on the same property as 3; 5, Jamieson's lime kiln quarry, in town of Renfrew; 6, Leitch's quarry near town of Renfrew; 7, Scott's quarry, near town of Renfrew; 8, Jamieson's second quarry, near Leitch's; 9, Bedford's quarry, east half of lot 9, concession 4, Ross.

Analyses

—	1	2	3	4	5	6	7	8	9
Insoluble residue							2.28	1.69	.10
Silica	.53	1.48	.36	1.86	.96	.73			
Ferric oxide	.50	.71	.50	.65	.41	.61	.50	.61	.28
Alumina	trace	.55	trace	.51	.87	.10	trace	.14	
Lime	51.12	50.16	52.50	51.62	46.00	50.74	49.62	50.64	31.10
Magnesia	3.31	2.81	2.23	2.15	7.34	3.98	4.17	3.59	21.21
Sulphur trioxide		.07	.30	.04	.25	.10	.06		.07
Carbon dioxide	43.68	42.35	43.41	42.16	43.62	42.18	43.44	43.74	47.23
Loss	.16	.65	.20			1.30			
Alkalies	.12	.21							
Total	99.75	99.02	99.50	98.99	99.45	99.74	100.07	100.41	100.02

"Dolomite.—From the sixteenth lot of the sixth concession of the township of Ross, Renfrew county, Province of Ontario. Geological position, Laurentian. Examined for Mr. W. P. Hinton. A beautiful, white, translucent, coarsely crystalline dolomite. Its analysis afforded Mr. Wait the following results (after drying at 100 degrees C.—Hygroscopic water equals 0.03 per cent. (213))

Carbonate of lime.......		55.32
Carbonate of magnesia... ..		44.54
Carbonate of iron..		0.11
Carbonate of manganese.......		trace
Phosphate of lime (tribasic)......	0.02	0.47
Alumina....	0.09	
Silica, soluble...... ...	0.17	
Insoluble mineral matter...	0.19	
		100.44"

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(213) G.S.C., 1899, p. 85 R.

Marl

"About 700 acres of the lower part of White Lake in McNab, under a shallow depth of water, in some places insufficient to float a canoe, and in others not exceeding two or three feet, present a bottom of shell marl, which, where tried in several spots, was found to possess a thickness of five to seven feet at least. There appears to be no deeper channel through this but a small flow of water escapes, notwithstanding the lake has an area of several square miles. It is discharged over a rim of crystalline limestone, and the bed of the brook falls rapidly after leaving the lake, so that an artificial drain could easily be cut, which would dry a great extent of the marl, a large quantity of which however could be dug out of the lake without draining at all.

"In the upper part of Mink Lake, north of the Bonnechere, near Jessop's Rapids, a deposit of marl extends out upwards of a quarter of a mile, where it has a thickness of more than nine feet, with two feet and a half of water over it, while there are only eight or ten inches of water nearer the shore. Other bays in the lake are also provided with marl bottoms. The length of the lake is about three miles, and a shoal, composed of the marl exists in the middle of it. At the outlet the water runs rapidly over boulders for the distance of a quarter of a mile, and there would be little difficulty in draining a few feet of the lake and laying bare a large quantity of the marl." (214)

"Shell marl is found in several lakes in considerable quantity, and should be of economic importance. Perhaps the most extensive of these deposits is in Mink Lake, Wilberforce township, Renfrew Co. Other lakes holding marl were found in Westmeath, and Ross. . ." (215)

"From a deposit on the twelfth lot of concession A, Coulonge Lake Front, township of Westmeath . . The deposit is about one hundred and thirty-five yards in length and some seventy-four yards in width. It consists of two distinct continuous layers—an upper dark-colored layer, twenty-two inches thick, and a lower light-colored layer, fourteen inches thick.

"(a) The material of the upper layer, in the air-dried condition, is earthy, slightly coherent; color light gray. It contains some shells, and also some rootfibres. A partial analysis of this, by Mr. F. G. Wait, showed it to contain (after drying at 100 degrees C.—Hygroscopic water = 0.99 per cent.); Lime, 52.31, which would correspond to 93.41 per cent. carbonate of lime; insoluble mineral matter, 0.88; organic matter—consisting of vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water—5.27; phosphoric acid, 0.04.

"(b) The material of the lower layer, in the air-dried condition, is earthy, loosely coherent; color yellowish-white. It contains some shells, but no visible root fibres.

"An analysis by Mr. F. G. Wait showed it to contain: (After drying at 100 degrees C.—Hygroscopic water = 0.29 per cent.)

Lime	51.68
Magnesia	0.51
Alumina	0.12
Ferric oxide	0.09
Carbonic acid	41.18
Sulphuric acid	0.03
Phosphoric acid	0.02
Silica, soluble	0.00
Insoluble mineral matter	4.06
Organic matter, viz., vegetable fibre in a state of decay and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	2.71
	100.49

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are however present in other forms of combination, the amount found would correspond to 92.28 per cent. carbonate of lime.

"The insoluble mineral matter was found to consist of: (216)

Silica	2.85
Alumina and ferric oxide	0.82
Lime	0.14
Magnesia	traces.
Alkalies (?)	0.25
	4.06"

Russell

The distribution of limestones of the Chazy formation and of the Trenton group are briefly described in the following notes:

"On the line of the Ottawa and Cornwall railway, about half a mile south of Embrun station, in a quarry of Black River limestone holding an abundance of fossils, the angle of dip is ten degrees to the northeast, but this formation is overlain by the Trenton limestone a short distance east of Embrun village to the northeast of this point." (217)

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(214) G.S.C., 1845-46, pp. 95-96.

(215) Ibid, 1895, p. 67 A.

(216) G.S.C., 1894, pp. 27-28 R.

(217) Ibid, Sum. Rep., 1899, p. 136

"The lower part of the Trenton does not appear to display any corresponding escarpments succeeding these. But about five miles and a half from the Ottawa, on the south side of the anticlinal, an escarpment of the upper part of the formation, varying from thirty to ninety feet, crosses the road between the eighth and ninth ranges of Cumberland, on the seventh lot. This is traceable in a pretty straight line for between seven and eight miles, to the line between Cumberland and Clarence, on the thirteenth lot, upwards of six miles from the Ottawa. Here it makes a sudden turn to the southward, and has been traced in this direction for about a mile. From 200 to 400 yards southward from the edge of this escarpment, the black shale of the Utica formation can be traced the whole way, presenting a very small dip to the southward until coming to the turn. A mile eastward of the turn a lower escarpment occurs, with another still lower, a mile beyond; both run northwestward for upwards of a mile, and present a small dip to the southward of west, indicating the crown of the anticlinal arch. The thickness in the three escarpments would probably be about a hundred and fifty feet.

"A great swamp extends nearly across Cumberland on the crown of the anticlinal, but on the north side of the anticlinal, limestones, which correspond with those of the uppermost of the escarpments, form a point on the third lot of the sixth range of Cumberland, about three miles and a half from the Ottawa. They present a considerable area of bare rocks, and upwards of a mile to the eastward are divided by a point of black shale. The limestones on the south side of the shale soon become covered up, in their progress eastward; but those on the north present an escarpment of about forty feet, facing the north, which is traceable for a couple of miles to the road from the Ottawa to Dunning's mills, where the road runs through the fourth range of Cumberland. On this road the escarpment is on the second lot; the outcrop of the black shales is about 650 yards southward from it on the third, where they form part of the smallest of the three patches of the Utica formation already mentioned, this smallest one being separated from the largest by the limestones on the Clarence and Cumberland anticlinal.

"Between the black shales and the Ottawa, the road which has been mentioned runs very nearly at right angles across the measures, and the breadth on it of the Trenton formation, with the Birdseye and Black River, is just about 5,000 yards. The dip, which is from the Ottawa, does not on the average exceed one and a half or two degrees, while there is a difference in level of about a hundred feet between the summit and the base. The total volume of the series would thus be between 650 and 700 feet, which accords very well with the supposed thickness both at Montreal and Ottawa.

"About two miles southward from McCaul's wharf in Clarence, the Chazy presents an escarpment of fifty feet, the base of which is occupied by the sandstone of the formation, and a short distance from this step there rises up another, the height of which is about a hundred feet. The lower part of it is occupied by the Birdseye and Black River formation, and the upper by a portion of the Trenton. This escarpment is on the southwest side of the Buckingham and Clarence anticlinal, and is well marked for at least two miles to the southeast. It is not yet ascertained how far the Birdseye and Black River formation is carried in this direction before meeting the dislocation which is connected with this anticlinal; but however far it may be, this formation is thrown northward again, beyond McCaul's mills, by the fault, the rock at the mills being Trenton.

"Freed from the effects of this fault, the same series presents itself in another escarpment, which, from a position about a mile west of McCaul's mills, runs in a nearly straight line to the tenth lot of the fifth range of Plantagenet, the distance being about eleven miles, and the bearing about five or six degrees south of west." (218)

"At the High falls on the South Petite Nation, in the twelfth lot of the sixth range of Cambridge, the river runs northward on the face of a single bed of Trenton limestone for about 300 yards, descending about 20 feet. The position and dip of this rock make it probable that it is on the north side of the main Rigaud anticlinal. The want of exposures in the stream for a considerable distance below the High falls renders it uncertain where the axis of the Templeton and Gloucester, and that of the Buckingham and Cumberland anticlinal would strike the stream." (219)

"Westward of the High Falls, at Cook's Mills, on the Castor, in the eighth lot of the ninth range of Russell, which would be in the strike of the strata at the High Falls, already alluded to, there is a section of about five feet, consisting of dark blue limestone alternating with black shale. Several of the shale beds are very fossiliferous. . . . On the south bank of the Castor, in the next range to the west, thick beds of dark blue limestone dip N. 40 degrees W. < 32 degrees: and further west, at Louck's mills, on the

(218) G.S.C., 1863, pp. 168-170.

(219) Ibid, p. 170, 171.

eleventh lot of the fourth range, the dip, which, on the south side of the stream, is S. 34 degrees W., at an inclination varying, in the distance of a hundred yards, from sixty to five degrees, is on the north side N. 40 degrees W. 17 degrees. While the north bank is occupied by thick bluish beds of granular limestone, the section on the south is as follows, in descending order :

	Ft.	In.
Black shale	3	6
Bluish-black limestone . . .	1	10
Black bituminous limestone	3	0
Black shale	0	4
Bluish black limestone	1	6
Dark bluish-grey limestone	2	4
	12	6

"These exposures on the Castor, which are in a nearly straight line from the High Falls, and in the direct continued bearing of the Rigaud and Fitzroy anticlinal, are shown by the irregularity of the dips to be probably affected by it. Two of them no doubt belong to the Trenton formation; but it is uncertain whether that at Louck's mill is to be placed immediately beneath the Trenton or at its summit. The thickness of the black shale associated with the limestone, and the fact that superior black shales occur not far to the north of the anticlinal, would seem to countenance the latter supposition, but at the same time the supposed position of the Chazy is not far removed to the west. To perplex the question still farther, a dislocation seems to be connected with the anticlinal near the spot, and it is not certain on which side of the black limestone it may run." (220)

Simcoe

Limestones belonging to the Trenton group, and to the Clinton and Niagara formations, together with calcareous tufa and marls, are found in this county. Excellent building stone is found and likewise material suitable for the manufacture of lime and for furnace flux.

Silurian Limestones

"Westward from Hog Bay, the whole of the peninsula of Penetanguishene appears to be enveloped in drift, but on an island in Georgian Bay beyond it, called the Giant's Tomb, the base of this series of limestone is met with, resting on the Laurentian gneiss, which occupies the northeastern half of the island. The upper members of the series are on the southeast side of Georgian Bay. They there compose the little islands called the Hen and Chickens, and may be observed about eight miles west of the Nottawasaga River, at McGlashan's mills, as well as at Hurontario, in the township of Nottawasaga; and at the contiguous corners of Nottawasaga and Collingwood, where they are seen to pass under the black shales of the Utica formation. The transverse breadth of the series is thus about thirty miles, and the thickness, supposing the dip to be southwestward at the rate of thirty feet in the mile, would be 900 feet: but it is not unlikely that the strata may be affected by very gentle undulations, and it would therefore be scarcely safe to state the amount at more than about 750 feet." (221)

"The upper portion of the Trenton limestone becomes interstratified with thin layers of black shales, which form a transition to the black pyroschists of the Utica formation. Similar black bituminous shales are interstratified a little higher up in the series among the grey and green shales and sandstones which constitute the Hudson River formation. These black shales in Canada, are highly calcareous, and often pass into impure limestones. Of two specimens of this kind from Collingwood, one gave to the dilute acids fifty-three, and another fifty-eight, per cent. of carbonate of lime, with a little magnesia and oxyd of iron. The insoluble snuff brown argillaceous residue from the former, when ignited in a closed vessel, gave off 12.6 per cent. of volatile combustible matter, leaving a coal black carbonaceous residue, which when calcined in the open air, lost 8.4 per cent. additional, and became ash grey. The insoluble residue from the second specimen was digested for some time with heated benzole, which took up from it about one per cent. of a solid brown bituminous matter. It then no longer gave the odor of bitumen when heated, but a smell like that of burning lignite. The matter which had thus been treated with benzole, still gave by ignition, 11.8 per cent of volatile and inflammable matters. It was not attacked by a boiling solution of caustic soda. Portions of this shale, when distilled in close vessels, give from four to five per cent. of oily and tarry matter, besides combustible gases and water." (222)

"Deposits of calcareous tufa occur in many places along the base of the

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(220) G.S.C., 1863, pp. 173-4.

(221) G.S.C., 1863, p. 193.

(222) Ibid, pp. 621-622.

Niagara formation in the counties of Grey and Simcoe. The most considerable known is on the banks of the Beaver River, in Euphrasia and Artemisia, which probably covers 1,000 acres. An area of about 300 acres of tufa, with an average thickness of five feet, occurs in a similar geological position at the falls of the Noisy River in Nottawasaga." (223)

Quarries

The composition of samples collected by myself is shown in the following table. Some very thick bedded rock occurs in the ravine near Singhampton. Two quarries were visited at Collingwood. The stone in that of the Cramp Steel Company is lithographic in character, and the quarry has a face of about 4 feet. Similar rock is seen in a quarry in the town. The formation here belongs to the Trenton group and lies little above the water level. A short distance away the escarpment rises and exhibits exposures of various Cambro-Silurian and Silurian formations to the top of the Niagara.

ANALYSES OF PALÆOZOIC LIMESTONES.

	1	2	3	4
Insoluble residue	......	......	......	.28
Silica	7.70	9.50	6.00	......
Ferric oxide	1.32	1.11	1.03	.41
Alumina	2.16	2.99	1.79	.40
Lime	45.52	45.30	48.34	30.06
Magnesia	1.42	1.67	1.61	21.40
Sulphur trioxide	.39	.38	.35	.04
Alkalies	.40	.60	.36	trace
Carbon dioxide	38.82	35.56	39.69	47.20
Loss	.30	2.14	.31	......
Total	98.03	99.25	99.48	99.79

Sample 1 was taken from the face of the Cramp quarry, Collingwood; 2 represents the loose pieces of stone in the same quarry; 3 is a general sample from Merchant's quarry in the town of Collingwood; 4 represents the rock at J. Gosset's lime kiln, near Duntroon.

The following results of analyses of the rock from the quarry of the Canada Iron Furnace Company of Midland have been kindly furnished by Mr. W Dixon Craig, chemist to the company. The quarry is on lots 19 and 20 in the fifth concession of the township of Tay. The formation is Black River. The quarry is situated on the shore of the bay, and the stone is carried to the furnace by scow, and is used as a flux in the smelting of iron ore. Some of the rock is fine grained and lithographic in character, like that in the township of Marmora and other localities farther east. The quarry has a diameter of about 100 yards and a face 12 or 15 feet in height.

—	Iron.	Silica.	Phos.	Alumina.	Alumina and Ferric Oxide.	Lime.	Magnesia.	Sulph.	Insol.	—
Quarry	......	......	......	......	1.00	......	......	.113	3.38	Near water.
"	......	......	......	......	2.45	40.03	10.36	......	4.39	Stock pile.
"	......	......	......	......	2.45	......	......	......	4.40	Dark stone.
"	......	......	......	......	2.39	42.65	8.14	......	3.46	Bottom layers.
"	......	3.61	.013	......	1.85	39.38	11.44	......	......	Stock pile.
Furnace	.10	4.41	.010	1.62	......	40.61	9.93	.092	......	" "
Quarry	......	4.14	......	......	2.35	39.82	10.09	......	......	S.E. portion—lower.
"	......	6.10	......	......	3.24	37.80	11.22	......	......	" " —upper.
"	......	4.61	......	......	1.67	38.93	11.92	......	......	West end.
"	......	5.58	......	......	1.67	38.07	10.93	......	......	Western half.
Furnace	.40	4.99	......	1.20	......	39.35	......	......	......	Stock pile.
"	.63	4.40	......	1.32	......	39.49	10.68	......	......	" "
"	.55	4.55	......	.68	......	39.42	11.51	......	......	" "
"	.69	4.15	......	.51	......	41.16	10.75	......	......	" "
"	.61	3.94	......	.68	......	42.56	8.51	......	......	" "
"	......	3.82	......	......	2.01	40.60	10.16	......	......	" "
"	......	7.14	......	......	3.66	38.43	10.11	......	......	" "
"	......	......	......	......	1.94	41.57	10.57	......	4.36	" "
"	......	......	......	......	1.90	37.95	......	.153	8.00	" "
"	......	......	......	......	2.06	38.27	10.41	.128	7.40	" "

Stormont

Exposures of limestones belonging to the Chazy, Black River and Trenton formations are found in this county.

"The Mille Roches quarries are in Black River limestones. These quarries are extensively worked for stone for canal construction, and blocks of very large size and of excellent quality are here obtained, one solid layer having a thickness of nearly ten feet. A short distance north of this the limestones of the Trenton come in." (224)

"Not far from Berwick, also, are ledges of dark bluish-gray [Chazy] limestone dip S. 40 degrees E. < 4 degrees. These beds extend northwest from this place as far as Cannamore post-office, and continue on in this direction." (225)

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(223) G.S.C., 1863, p. 304.

(224) G.S.C., 1899, p. 135 A.

"The Trenton is also well exposed near Mr. Henry Onderdonk's, a short distance to the northwest of Aultsville. It also appears about Crysler in the township of Finch, Stormont county, and thence eastward towards Moose Creek.

"Near South Finch, the bed of the Payne River consists of Trenton limestone, and there are also fine exposures about South Finch, Lodi and other points in the vicinity." (226)

"On the north shore of the St. Lawrence, at a small point opposite the northeast corner of Barnhart Island, there is a fine exposure of greenish and black Chazy shales. They are very concretionary and nodular in places, but no fossils were observed. The dip is N. 10 degrees W. < 2 degrees. These shales are exceedingly thin and splintery and are easily crushed in the hand." (227)

Thunder Bay District

Very little has been done in the limestone industry in this district.

Lime, cement and other products are shipped into the district by water at a low cost for freight. Attempts have been made at various times, as the following notes show, to work some of the limestones for decorative purposes.

The marl deposits, such as those which are found in some of the small lakes along the line of the Port Arthur, Duluth & Western Railway, are likely to be of economic value in the future, other forms of limestone being comparatively scarce.

The calcite vein-material which occurs in considerable abundance in some of the deposits in the silver-bearing areas may also be utilized in metallurgical work.

Lake Nipigon

"Nowhere about the lake [Nipigon] are the sedimentary rocks of the Nipigon series seen in any great volume. The mass of the strata exposed about the shores, and forming high bordering hills, is trap, with only here and there a thickness of from six to fifteen feet of limestone or sandstone underlying it at about the water level. On the southern and south-western sides of the lake limestones are the only sediments met with, and on the southern and north-eastern sides, highly silicious red and white sandstones (which become locally quartzites), take the place of the limestone under the trap. These sandstones lie directly upon the Archaean gneiss, and seem to be littoral beds, which mark the shore limit, in this direction, of the basin in the deeper part of which the limestones were deposited. . . . . Some of the sandstones, limestones, etc., about the lake would afford good building stone." (228)

"On the southern point of the Inner Barn, in Wabinosh Bay, I discovered near the water's edge a section of about ten feet of mottled, green and purple, shaly arenaceous limestone, dipping easterly at an angle of 15 or 20 degrees. Beds of a purer limestone, having a gray and greenish color, mottled with purple patches, are interstratified with the others, and fragments derived from them are strewn in abundance upon the beach, and may prove of value for burning into lime." (229)

Albany River.

"All the way from Martin's Falls to the forks, the Albany is flanked by steep banks, either immediately overlooking the water, or rising at a short distance back from it. In descending the river their general height increases gradually from forty to about ninety feet, and they also become more regular and continuous in approaching the forks. They are at first composed entirely of drab-colored boulder clay, capped with sand, but, after reaching the Palaeozoic rocks these deposits are by degrees replaced in the lower part of the banks, by drab and chocolate-colored marls, and shales, the upper part being usually composed of the boulder clay, overlaid by sand. The bed and shores of the river consist of either smooth, flat-lying rock, or small rounded boulders, packed closely together, and all brought by the drifting ice to a uniform surface, so that they bear a strong resemblance to a well-laid pavement.

"Gneiss, with the usual east and west strike, was the only rock seen in situ from Martin's falls to the most northern point of the great bend; but, immediately on passing this, yellowish limestone strata make their appearance in the bed of the river. Similar limestones and others of a gray color, are seen in the bed and banks of the river, here and there, to within about twenty miles of the Forks, where they become replaced by the overlying drab and chocolate-colored marls and shales. The inclination of the strata towards the sea is greater than that of the bed of the river, so that the line of division between the chocolate-colored and the underlying drab marls and shales becomes gradually lower and lower in the banks, and at length sinks beneath the river bed. Layers of the two colors are interstratified with each other for a certain thickness at the junction, so that for some miles the banks have a banded appearance. In this interval a small quantity of soft, thin-bedded gray sandstone occurs. The few fossils found in these rocks appear to indicate an equivalent of the Niagara formation" (230).

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(225) G.S.C., 1896, p. 62 A.

(226) Ibid, p. 63 A.

(227) Ibid, p. 62 A.

(228) G.S.C., 1894, pp. 50, 51 A.

(229) Ibid, 1871-1872, p. 104.

"In the Report of the Survey for 1871-72 Professor Bell mentions (p. 106) an 'indurated, pink-colored calcareous marl' which occurs in horizontal beds on the Pikitigouching River. A specimen which he requested me to analyze was collected by his assistant, Mr. Lount. It contained:

Silica	39.87
Alumina and ferric oxide	9.34
Lime	22.40
Magnesia	6.24
Carbonic acid	23.40
	101.25

"The residue left after treatment with hydrochloric acid amounted to 42.84 per cent. of the rock" (231)

"The Black Bay Mine & Quarry Company has its principal office in Chicago and its western office at Duluth. It has been organized to acquire and work a location of jasper and dolomitic limestone in the township of Dorion, near the north shore of Black bay. The property was not secured until late in 1891, and only specimen blocks have been taken out. Both kinds of stone are beautiful in color, and take a fine polish, but the specimens seen are more or less flawed, owing no doubt to the influence of the weather on rock so near the surface. The following account of the quarry has been furnished by A. M. Stearns of Duluth, manager of the company:

'The company's lands as patented by the Crown are described as the west half of lot 3, concession 4 of Dorion, containing 146½ acres.

'The property lies about one and one-tenth mile from navigable water in Black bay, upon the Canadian Pacific Railway. The outcropping of quarry stone occurs about a quarter of a mile west of the railway, on a gradually-ascending slope, at about 100 feet altitude, and lying between immense granite hills on the northerly and southerly sides.

'It has been noted and commented upon by explorers as a peculiar formation, but it was left to our company to demonstrate that it is a very large and valuable bed of jasper, underlaid with a stone so like mahogany when polished that we offer it to the trade as mahogany stone. The jasper lies at and near the surface, is from three to five feet in thickness, and can be quarried in blocks about three feet wide by five to seven feet long.

'The mahogany stone upon which the jasper rests occurs first in thin beds, which soon thicken to an apparently unstratified ledge, and may be quarried in even larger sizes than the jasper.

'Though harder than marble, the jasper saws readily, and can be satisfactorily reduced with hammer and chisel, taking a polish equal to plate glass.

'If one-third of these measurements be allowed for dressing we shall have net dimensions remaining without flaw suitable for wainscoting, tables, mantels, sideboards and sizes suitable for turned columns and carved pedestals in fine architectural work.

'The whole formation dips slightly to the northwest, and judging from the number and uniformly sloping surfaces of the several exposures and the slight stripping between them, as far as tests have been made, must cover an area of at least forty acres.

'The color and the polishing qualities of stone taken from this location will readily commend it to public favor, and should it, as may reasonably be assumed, prove to be free from flaws when a greater depth from the surface is reached, it ought to find a ready market.'" (232)

Victoria

There is a considerable variety of limestones in this county. They consist of the ordinary stratified rock of Cambro-Silurian age, crystalline limestones or marbles, which belong to the Laurentian system, and marls of recent age. Many of the outcrops of these rocks are well situated for shipping. A sketch of the distribution of the Silurian strata is given below, together with a series of analyses of samples of these rocks from the neighborhood of Coboconk and Burnt River P.O. These analyses show the general character of this group of rocks throughout the county.

"It [the Trenton escarpment] crosses Buckthorn Lake at the strait, about two miles and a half above Buckthorn Falls, and then, again separating into two parts, the main one strikes nearly straight by Sandy and Pigeon Lakes to the head of Balsam Lake, the inferior escarpment keeping about a couple of miles to the northeast." (233).

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(230) G.S.C., 1871-72, pp. 111-12

(231) Ibid, 1874-75, p. 312.

(232) B.M., Vol. I., p. 100.

"In the continuation of this course westward [from Burleigh falls], the cherty beds [of limestone] with their characteristic corals, are displayed at the top of the cliffs, which rise over the exit of Buckthorn Lake. They are seen too on Pigeon Lake, and at the Bobcaygewan Rapids, near the foot of Sturgeon Lake. On the north part of Balsam Lake, in a great bay on the west side, they occur on the land of Mr. Stephenson in block E of Bexley, where they incline at a very small angle southward. . . .

"The base of the inferior escarpment is seen at the foot of Mud Turtle Lake, near where the continuation of the line between the eighth and ninth ranges of Somerville would cross it, about three miles north from the northeast bay of Balsam Lake. The base consists of pale drab limestone of fine texture, in very regular layers of from three to six inches, without fossils, and over it an escarpment rises a little way south to the height of forty or fifty feet. The upper beds are massive and fossiliferous, but the fossils are very obscure. Among the fossils a small Leptaena was observed to be very abundant, and another bivalve was occasionally found with encrinites and fucoids, but the specimens are too ill defined to be easily identified.

"At the rapids at the outlet of Balsam Lake there are flat surfaces of limestone exposed just over the edge of the water, with fossils weathering in relief. . . . At Fenelon Falls, near the exit of Cameron's Lake, where there is a section of about twenty feet in the gorge of the river below the cascade, the following Trenton species occur : . . . .

"On Sturgeon Lake, opposite the mouth of Scugog River, where the strata are of greenish calcareous shale, with very thin beds of limestone, the fossils in greatest abundance are, etc.

"At the village of Lindsay on the Scugog River, in Ops, there is a small exposure of blue limestone in beds of six or seven inches, interstratified with blue calcareo-argillaceous shale, holding abundance of fossils." (234)

In the township of Somerville escarpments of limestone of Black River age surround a somewhat semicircular area lying to the westward of the railway at Burnt River station. The ledges rise to a height of 40 or 50 feet. Britnell's quarry lies about three-quarters of a mile south of the station, alongside of and to the west of the railway track. In ascending order the layers of limestone in this quarry are as follows : 5 beds averaging 12 inches in thickness; followed by bed of shale and transition sandstone 12 inches; 4 feet made up of thin beds, followed by three beds of lithographic character of 2 feet 9 inches, 6 inches, and 1 foot 4 inches in thickness; then there are 4 layers of 7, 9, 12, and 8 inches respectively; the top layer has a thickness of 2 feet. The beds have a slight dip to the southwest. The stone makes a good building material, and the refuse, after being passed through a No. 3 Gates crusher, is used as a road metal, and for concrete work in Toronto.

There is an important lime industry at Coboconk, where the two kilns in use have a combined capacity of 135 tons (70 lbs. to a bushel), a week. The rock burned here is similar to that in the escarpment at Burnt river. The nine upper beds in the quarry used for lime have an aggregate thickness of 18 or 20 feet; under these beds are layers which are said to be unsuited for lime-burning but make good building stone. They have thicknesses of 14, 2, 4 and 9 inches respectively. They are fine-grained and lithographic in character. The soft wood used in the kilns costs from $1.50 to $1.75 a cord. Coboconk lime is used in the production of acetate of lime, at the Longford charcoal plant.

The results of several analyses of the rock from Coboconk and Burnt river are given in the following table :

ANALYSES OF LIMESTONES FROM COBOCONK AND BURNT RIVER

—	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Insoluble residue..															
Silica....	.96	.98	1.60	1.56	.72	1.68	3.94	11.34	1.00	1.62	1.68	1.70	1.50	1.38	1.44
Ferric oxide	.95	.39	.65	.52	.41	.65	.82	1.52	.40	.57	.30	.40	.49	1.62	.23
Alumina		.30	.11	.39	.80	1.14	1.57	4.72		.33	.52	.60	.39		1.03
Lime	54.00	54.40	52.40	51.44	50.31	47.28	45.74	28.10	49.34	52.88	53.06	53.00	52.40	54.00	52.60
Magnesia..........	.70	.69	.74	1.37	2.72	5.46	4.40	4.92	3.79	.76	.29	1.18	.74	.81	.73
Carbon dioxide ...	42.95	43.00	40.44	41.83	42.30	43.30	40.84		42.78		41.82	43.04			43.49
Water															
Loss	.71	.36	2.55	1.41	1.25				.84		1.92				
Sulphur trioxide ..	.39	.14	.25		.37		.39	.31	.27	.35	.38	.40	.20	.28	.47
Alkalies	.22	.11					.21			5.05		trace			.05
Total	100.88	100.67	98.71	98.52	98.88	99.51	97.64		98.42		99.37				100.04

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(233) G.S.C., 1863, p. 189.

(234) Ibid, pp. 190-191.

1.—General sample of rock used for lime burning at the Coboconk kilns. 2.—Lower layer of limestone in the quarry at the Coboconk kilns. I was told that this layer was considered unsuited for lime burning. There is no reason for this, as the composition of the rock is shown by analysis to be almost identically the same as sample 1. A general sample taken from the outcrops just east of Coboconk has the composition shown in column 3. Samples 4, 5, 6, 7 and 8 were taken from Britnell's quarry, Burnt River. 4.—Top layer, 2 feet. 5.—4 feet 10 inches, of the upper part of the face of the quarry, 6-3-feet bed, just below top layer. 7.—4 feet, immediately above silicious layers. 8.—The two silicious beds at the bottom of the quarry. 9.—Lower layers of cliff, lot 11, concession 8 of Somerville township. 10.—Upper 15 feet of the same cliff, facing south. 11.—Upper 15 feet of hill on 7th line. 12.—Lower layer, side line, lot 14, concession 6 of Somerville. 13.—Lower 6 feet on hill, 7th line Somerville. 14.—Second 15 feet, about half way up hill, 7th side line. 15.—Crystalline limestone from marble quarry, near river, said to have been opened by Judge Dean.

It will be seen from the table that the upper parts of the limestone ledges and cliffs in the vicinity of Burnt River P.O. are similar in composition to those of Coboconk. Considering that samples 10, 11, 12, 13, 14, represent surface specimens, and hence would be expected to run higher in silica and lower in lime than if they were taken from rock freshly broken in a quarry, their agreement with 1, 2 and 3 is very close. Samples 4, 5, 6, 7, 8 and 9 represent beds of rock which lie at a lower level than those just mentioned. This accounts for their higher average percentage of magnesia, and the comparatively [illegible] percentage of silica in 7 and 8. The last mentioned sample, 8, is a sandy limestone, and apparently represents a transition from the overlying limestones to underlying sandstones or conglomerates which are usually found at the base of the series in this region.

The last sample, 15, considering that it is crystalline limestone, is comparatively pure.

There is a small quarry on lot 8 in the eleventh concession of Somerville, some distance northeast of the station, and near Burnt River. This quarry is in crystalline limestone. It was opened years ago in an endeavor to use the limestone as a marble. An analysis of a sample, 15, from this quarry is given in the table.

Dolomite from Coboconk, township of Bexley. "This stone has a light greenish-grey color, is very fine crystalline, and has a close and uniform texture.

"Agreeably with the results of an analysis, conducted by Mr. F. D. Adams, it contains—after drying at 100 degrees C.: (235)

Carbonate of lime	50.745
Carbonate of magnesia	35.532
Insoluble matter	9.960
	96.237

Marl

"Location at Manilla, Victoria county, Ont. An analysis of this marl runs as follows: (236)

	Per cent.
Moisture	0.20
Organic matter	1.61
Clay and sand	0.50
Lime (CaO)	53.27
Magnesia (MgO)	0.77
Iron and alumina (Fe_2O_3 and Al_2O_3)	0.59
Alkalies	trace
Carbonic acid (CO_2)	42.60
Phosphoric acid (P_2O_5)	0.28
Soluble silica (SiO_2)	0.12
	99.94"

Waterloo

The characteristics and relationships of the limestone formations in Waterloo county are described in the subjoined extracts from various Reports of the Geological Survey:

"The fall from the base of the [Guelph] formation, at Guelph, on the Speed, to the bed of the Grand River, at Breslau, as deduced from the levels on the Grand Trunk Railway is eighty-two feet. The distance across the strike of the measures, between Guelph and Breslau, is about nine miles, so that if the dip of the strata be taken at twenty feet in a mile, which is perhaps near the truth, the base of the formation would be one hundred feet beneath the bed of the Grand River. The rocks of the Guelph formation are not seen at Breslau; but at points both to the north and to the south, which would include this place in their strike, strata are met with at a level of about sixty feet above the Grand River. This would give for the Guelph [formation] dolomites, about 160 feet; which we may assume as the approximate thickness of the formation.

"The strata of this formation appear, so far as examined, to be magnesian limestone, having the composition of true dolomites, and are frequently made up of brilliant crystalline strongly coherent grains. The rock is very often porous, and has small drusy cavities besides which are those forming the moulds of fossils. In many cases the shell appears to have been simply enveloped in the rock; and having been afterwards removed by solution, it has left a corresponding cavity. At other times, the interior of the shell was also filled with the dolomite, so that the mould corresponds only to the thickness of the shell; the markings of both the interior and exterior of which are thus preserved. More rarely, the cavities have been subsequently filled up with calcareous matter; so that the substance of the shell appears to have been either replaced or preserved.

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(235) G.S.C., 1882-84, p. 2 MM.

(236) Cat. Ont. Min. Exhibit, Buffalo, p. 81.

"The most southern exposure of the summit of the formation, on the Grand river, occurs just above Middleton bridge, on the twenty-first or twenty-second lot of the sixth range of Dumfries. The rock is a pale drab. Similar beds with others of a pale buff color, continue up to the north end of the fourteenth lot of the sixth range of Dumfries, with a very gentle dip to the southwest; the distance across the measure being probably two miles. . . The rocks of the Guelph formation are again met with, farther up the Grand River, in the vicinity of Galt.

"The highest strata here appear to be the same as those above Middleton bridge. The exposures are chiefly on the right bank of the river, but occasionally on both banks, and they extend for some distance, both below the town and above it, where quarries are wrought in the rock. The greatest vertical section in any of these is thirty-four feet; but exposures of both higher and lower strata would make the whole thickness upwards of sixty feet. At the top of the formation, in this neighborhood there are about eighteen feet of hard, thin-bedded bluish dolomite, beneath which are thirteen feet of pale buff or white dolomite; succeeded by twenty feet of yellowish-white and greyish-white crystalline thick-bedded dolomite, in overlapping lenticular masses. The whole mass holds fossils, but these in the immediate vicinity of Galt are most abundant in the twenty feet of pale buff thin-bedded dolomite in the middle of the section. . . .

"The exposures continue all the way to Preston, which is still higher up on the river. Here the banks exhibit a section of from fifteen to twenty feet of coralline, magnesian limestone, probably equivalent to the thin-bedded pale buff dolomite of Galt, but not so fossiliferous. Exposures continue up the Speed; and at Hespeler strata occur that are lower in the series than those at Galt; their stratigraphical place being probably near the middle of the formation. A cutting at Hespeler, on the Great Western Railway, exhibits fifteen or twenty feet of pale greyish-white strata, which are not so massive as some of those at Galt, but more fossiliferous. . . Both at Galt and Hespeler, quarries are worked in these magnesian limestones which yield excellent building stones, easily dressed and probably durable. Some of the beds are burned for lime, which is often rather dark in color, but makes a strong mortar." (237)

"Exposures of strata belonging to the Onondaga formation, are met with at several places on the Grand river, for a distance of about 15 miles; from Doon, six miles above Galt, to about 2 miles below Glen Morris. Between Galt and Preston, on the west side of the river, on a lot adjoining one where the Guelph formation is exposed, there are seen about 5 feet of brownish shale, interstratified with thin beds of dolomite; in one of which is found an obscure bivalve shell. Similar strata are said to occur 2 miles below Glen Morris; beyond which the rocks of the formation are concealed beneath a great thickness of drift." (238)

At the present time the only large limekilns in this county in continuous operation are at Galt and Hespeler. At the former place there are two draw kilns and at the latter, one, the lime produced at each being white. The same limestone is used locally for rubble and road-metal.

Marl

"From Paris towards Ayr the rough morainic deposits gradually give place to gravel beds, while from Ayr to Galt sand and gravel alternate with clay. Throughout this region are numerous marl beds, many of which will doubtless prove valuable for the manufacture of cement. A cursory inspection was given to a few of these deposits as follows:

"The farm of Walter J. Reid, lot 31 in the tenth concession of North Dumfries, shows about twelve acres of marl and four acres of lake. Clay is seen on the south side of the lake, but fine sand is the predominating superficial deposit.

(237) G.S.C., 1863, pp. 337-340.

(238) Ibid, pp. 350-1.

"The farm of Mrs. McCrone, lot 29 in the eighth concession of North Dumfries, contains ten acres of lake and ten acres of low land covered by marl. Close to the shore, bottom could not be obtained in a continuous mass of marl with a 16-foot pole. The lake is very deep, but notwithstanding this objection a very large quantity of accessible marl doubtless exists here. Another lake lies to the south and west; about thirty acres of low lying land intervenes. I have no doubt that this tract is largely composed of marl. Clay does not appear to be plentiful in this vicinity, light land with many stones being the prevailing soil.

"A small lake of three acres with marl is seen to the northwest of this point on the farm of Mr. Taylor, while southward, on the property of Robert Easton, there is an excellent deposit in and surrounding a lake of ten acres bounded by low land, said to show plenty of clay.

"A glance at the township plans of this vicinity will impress on the reader the large number of small spring-fed lakes in this region; while it was impossible to visit more than a few of these, it is extremely likely that they are of the same nature as those seen, in which case we have here numerous sites for the manufacture of that product for which the demand is increasing with strides and bounds—Portland cement." (239)

Welland

The Clinton, Niagara, Onondaga Lower Helderberg and Corniferous limestones, which occur in this county are briefly described in the following notes. There is much information available concerning the underground geology of the county, as numerous wells have been drilled in search of gas.

There are important quarries in the vicinity of Port Colborne and Sherkston, in the Corniferous formation, where lime is produced. Rock has long been worked at Thorold and elsewhere in the production of natural cement. The Port Colborne and Sherkston quarries produce rock which has been used as a furnace flux and in the manufacture of calcium carbide.

Clinton Formation

"In Canada for reasons which will be stated in describing the Niagara formation, it is found convenient to limit the Clinton to the strata beneath the Pentamerus band, and to include this band in the Niagara formation. On the Niagara River, the Clinton is thus limited to a few feet, but it gradually augments in thickness to the northward.

"In the cutting of the Welland Canal at Thorold, about seven miles to the west, the Grey band is a white fine grained sandstone, somewhat irregularly deposited; the beds thinning out, and occasionally coming to wedge-shaped terminations. When of sufficient thickness, they afford excellent material for the purposes of construction, and altogether constitute a mass of about ten feet. Immediately above this band the Clinton appears, consisting of four feet of bluish and greenish argillaceous shale, presenting fucoids on the surfaces of the beds; among which are fine examples of Arthrophycus Harlani, especially near to the underlying sandstone. The shales here show no indication of the fossiliferous iron ore beds.

"At Mr. Goodenow's quarry, about a mile and a half west from the village of Thorold, and immediately above the Grey band, which is there ten feet thick, there occur the following Clinton strata, in ascending order: (240)

	Ft.	In.
Bluish-green argillaceous shale	4	0
Bluish-grey limestone, abounding in iron pyrites for an inch on the top...........	2	9
Bluish-drab argillaceous limestone, yielding a hydraulic cement.....	3	1
	9	10

Niagara Formation

"The bluish-black shales which in the state of New York afford a well-marked division between the Clinton and Niagara formations, are available for this purpose but for a short distance in Canada. To the northward these shales thin out and disappear; and it is for the present very difficult to distinguish them in that direction. We therefore propose to include in the Niagara series, the two bands of limestone which underlie the shales, and which, in New York, constitute the upper part of the Clinton formation. So far as they have been examined in Canada, these two limestone bands contain no Clinton fossils, but such as pass upwards into the Niagara; the upper band here possesses one or two species, which, in New York, are considered to belong to the latter group only. There would thus appear, at present, to be no paleontological reason why these limestones may not be considered the base of the Niagara formation; while geographically they present a very marked feature for a considerable distance, and afford a convenient means of describing the distribution of the two formations.

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(239) B.M., Vol. XII p. 149-50.

(240) G.S.C., 1863, pp. 312-3.

"Including these limestones, the Niagara strata seen in the cutting of the Welland Canal, near Thorold, in immediate succession to the Clinton formation, are as follows, in ascending order:

"1. Bluish-grey magnesian limestone, with partings of bluish calcareous shale. Concentric rings of discoloration are observable around small cavities lined with calcspar, which occur generally at the surface of vertical joints, cutting the strata at right angles. The circles are usually so large as to cross the divisional planes of several beds. Pentamerus oblongus and Stricklandia canadensis occur in abundance; 10 feet.

"2. Grey coarse-grained sub-crystaline limestone, with disseminated iron and copper pyrites; the bed abounds with fossils, among which, on the canal, are Atrypa reticularis, Rhynchonella cuneata, and Athyris cylindrica; 10 feet.

"In the upper five feet of this bed, in Mr. Goodenow's quarry, a mile and a half to the westward, there are fragments of an undetermined species. . .

"3. Bluish-black bituminous shale, with thin bands of impure limestone, holding trilobites and a few shells. Among the trilobites, Dalmanites caudatus is frequent. In some places, thin bands of gypsum occur, giving a riband-like aspect to the shale. Small nodules of gypsum are also sometimes met with, as well as crystals of iron pyrites. This shale constitutes the base of the Niagara group of New York; 55 feet.

"4. Bluish-grey argillaceous limestone, yielding excellent water cement, which was much used in building the locks of the Welland Canal; 8 feet.

"5. Dark bluish bituminous limestone, in some places yielding material fitted for purposes of construction, as at Mr. Keefer's quarry at Thorold. The upper and under surfaces of adjacent beds are often united by suture-like joints; the parts interfitting being sometimes two inches in depth, with vertical columnar sides, usually glazed with a thin pellicle of argillaceous matter. Crystals of galena are frequently met with in these beds, which contain many fossils; 8 feet.

"6. Light and dark grey magnesian limestone, in beds varying from 6 to 10 feet in thickness, constituting a building stone of the best description. It is a cemented mass of encrinites, with a few additional fossils, and in some parts holds geodes filled with snow-white gypsum; 26 feet.

"7. Bluish bituminous limestone well suited for purposes of construction, though inferior to the preceding mass. It holds many fossils, principally corals; 7 feet. Total, 124 feet.

"This section represents all the beds of the series which are crossed on the canal, up to the highest part of the ridge, near Thorold; but it does not reach the summit of the series by probably ninety feet. Proceeding westward, the volume of the black shales diminishes, while that of the limestones beneath them augments." (241) (See under Wentworth.)

Onondaga Formation

"Running parallel with the shore of Lake Ontario, it [the Onondaga formation] diminishes considerably to the westward, until it crosses the Niagara River, and enters Canada, with a thickness which is estimated at between 200 and 300 feet. . . . .

"Commencing at the Niagara River, the upper beds of the series are seen near the village of Waterloo, and are traceable to the westward, from the eighth lot of the seventh to the twenty-third lot of the second range of Bertie. Sweeping round towards the shore of Lake Erie, behind Cape Abino, through the influence of an undulation, they are again traceable, from the fifteenth lot of the third range of Humberstone to the Welland Canal, on the twenty-sixth lot of the second range of the same township. Between this outcrop and the Chippewa, the whole of the country is covered by clay. It is probable however that the lowest beds occur somewhere near to Chippewa village, as the clay for a considerable extent in that neighborhood has a red color, such as might be expected from the disintegration of the red shales, which occur at the base of the formation in New York. The same red color also prevails on the Welland Canal, in the vicinity of Port Robinson, though no red shales have yet been seen in place, either there or for upwards of a hundred miles beyond.

"The exposures of the Onondaga formation in Canada, so far as yet examined, appear to belong chiefly to the upper portions, from the summit to a little below the gypsum-bearing beds. These portions consi[illegible]mites and sof[illegible] crumbling sh[illegible] re greenish [illegible] sometimes [illegible] and are o[illegible] are mos[illegible] color, [illegible] ceed [illegible]

(241) G.S

hibit the vesicular or the lenticular cavities just described. Some beds of a bluish dolomite are also met with, and many of the strata, both above and below the gypsum, contain such a proportion of clay as make them fit for hydraulic cement." (242).

Lower Helderberg

"The Water-lime series [Lower Helderberg], as thus defined, enters Canada opposite to Buffalo, and can be traced pretty continuously in a band varying from twenty to forty-five feet in thickness. This series has been found to exhibit its characteristic fossils, in three localities in Canada. One of these is on the fifth lot of the tenth range of Bertie, where the following ascending section occurs: (243)

	Ft.	In.
Dark bluish-grey shaly dolomite	1	0
Light bluish-drab dolomite (water-lime), in beds of from one inch to one foot	3	6
Gray dolomite beds from one to eight inches	10	0
Measures concealed in an escarpment, which rises from the previous bed, but supposed, from fragments by which they are covered, to be of the same character as before	6	0
	20	6"

"Summing up the observations in the region described so far, we find that the lowest rock exposure is the so-called water-lime belonging to the Lower Helderberg formation of the New York geologists. It is mentioned in the Geology of Canada, 1863, page 354, as entering Canada opposite Buffalo, and as being exposed at various points, of which the particulars may be found as above cited. In the Report of the Bureau of Mines, 1902, page 34, Professor Coleman gives an analysis of this rock; his results, as well as others prepared for this Report and already mentioned in previous pages are tabulated below:

"The reader should compare this list with the analysis of the famous Rosendale cement rock, quoted by Professor Coleman in the Report above mentioned. It will be seen that all these analyses agree quite closely except that of the rock from Best's quarry, which shows an unusually high percentage of alumina. This rock seems not to attain a greater thickness than 40 feet, and is overlaid by the Oriskany sandstone, which presents two varieties, as already mentioned, a hard quartzite-like example, and a more friable sort composed of rounded grains of quartz with some feldspar. This rock is found just west of Port Colborne, where it forms a bed not over a foot thick. The position here, which is distinctly between the Water-lime and the Corniferous, is maintained, but with increasing thickness, towards the north, reaching south of Hagersville a maximum of about twenty feet. However, if we have rightly interpreted the well at Stratford, a thickness of 117 feet is attained at that point." (244)

Corniferous

"The formation enters Canada from New York, nearly opposite Buffalo, and is traceable, in a narrow belt, along the shore of Lake Erie, resting on the Oriskany sandstone; or where this is wanting on the Water-lime series. At Horn's quarry in Bertie, two miles below Ridgeway station, on the railway, there is a section of nearly twenty-four feet, and at various points on the lake, or at a short distance inland, sections of from ten to twenty feet have been observed, as far as Woodhouse and Middleton. In many parts it is quarried for building purposes; while some portions abound in chert, which forms beds of from one to four inches, or exists in nodules like flints in the limestone. Many of the beds contain silicified organic remains. These, in some localities, as in North Cayuga, and at Port Colborne, are found weathered out and loose, in great abundance, at the surface of the ground. Some of the beds are little more than an ag-

Locality.	Lime.	Magnesia.	Alumina and Iron Ox.	Silica.	Water.	Carbonic Acid
Lot 28, Con. II., Humberstone........	25.02	16.81	4.94	12.32	0.06	39 13
Best's Quarry...............	20.09	14.41	25.26	4.14	0.55	.... .
Quarries south of Hagersville	26.61	17 49	4.20	3 44	0.35	41.96 loss.
Springvale......	31.58	17.79	5.18	3.69	0.15	44.73 loss

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(242) G.S.C., 1863, pp. 349-7.

(243) Ibid, pp. 353-4.

(244) B.M., Vol. XII., pp. 152-3.

gregate of silicified organic remains, with so little calcareous matter that the whole mass coheres after the carbonate of lime has been dissolved out. The Corniferous limestones, unlke the great mass of the Middle and Upper Silurian strata, in Western Canada [southwestern Ontario], effervesce freely with acids, and are not dolomitic. Som of the beds are marked with epsomites, as on the lake shore near Port Dover, where these impressions occur between layers of limestone and chert; the latter being apparently the overlying bed. These strata are often highly bituminous: petroleum is found in many places, filling the pores of the corals, and in one case a drusy cavity in a Pentamerus." (245)

"In working Mr. Horn's quarry, which has already been mentioned, on the thirteenth lot of the second range of Bertie, the oil is seen to impregnate particular beds, which are in great part made up of the remains of a species of Heliophyllum. These corals, in various attitudes, are arranged in bands varying in breadth from three to six inches, and in their open cells petroleum is lodged. The intermediate parts of the rock, which contain no oil, are composed of a mass of broken organic remains, chiefly encrinites, while in the coral-bearing beds these comminuted crinoids serve as a paste to fill up the interstices among the corals." (246)

"According to Mr. J. C. McRae, who was good enough to serve as guide to the region, the Corniferous limestone near Port Colborne is not more than 25 or 30 feet thick, the water-lime lying beneath it, and as one may see in Wainfleet township a thin sandstone, probably Oriskany, overlies it. The latter rock is a coarse-textured, pale gray stone, only a few inches or a foot thick where we saw it, fitting into all the fissures of the limestone below, as if the lower rocks had weathered before the sands were deposited.

"The Corniferous furnishes excellent material for lime-burning, and Messrs. Reeb & Sons have five large lime kilns some distance west of Port Colborne, near the shore of lake Erie. The limestone in their quarry is ten to fifteen feet deep, and the stone is unusually pure, containing, it is said, only a trace of magnesia. It is shipped to Hamilton as flux for the iron smelter and also to the carbide works. A large amount of lime is burnt in the kilns by a continuous process, natural gas being used as fuel" (247)

Limestone from the quarry in the Corniferous formation at Sherkston is shipped in large quantities to the iron and steel plants at Buffalo. Lime is also produced at the quarry, natural gas being used as the fuel. The cut gives a view of the kilns.

Brown's Quarry

"This quarry is in the township of Stamford, on the line between that township and Thorold, and consists of 11½ acres. It was opened about forty years ago by Messrs. Brown & Zimmerman to procure stone for the old canal, and was worked again in 1874 by Belden & Co, during the construction of the new canal.

"The land is the property of Mr. James Brown, but the three quarries upon it are worked under lease by Messrs. Walker Bros. of Merritton; they have been opened to a depth of eighteen feet.

"There are two bands of limestone, the upper of yellowish-gray and the lower of gray color. Under the gray is a bed of blue limestone, which however cannot be worked for want of drainage. Stone from the upper band is used for curbing, street crossing, flagstones and bridge works, and from the lower for monument bases and window sills.

"The firm have a mill at Merritton, which runs a gang of ten saws, where stone is cut for window sills, flagging, street curbing, etc. Four quarrymen and three stone-cutters are employed at the quarries.

The Mountain Quarry

"The Mountain quarry is on parts o. lots 4 and 5 in the township of Thorold, on the town line between Stamford and Thorold, and consists of 28⅓ acres. It is owned by Mr. William R. Cartmell, and has been worked by him since 1854, a large quantity of stone having been taken out.

"About twelve feet of clay covers the limestone here, which has been stripped from an area of three or four acres.

"The quarry has been worked to a depth of twenty-two feet, yielding two qualities of stone. The upper bed, which is nine to ten feet in thickness, is of dark blue color and poor quality, the courses ranging in thickness from two feet at the top to six or eight inches at the bottom of the bed; the stone is used chiefly for backing work.

"The lower bed is twelve feet in thickness, and is of light gray color. It is a fine-grained stone, and is used for bases of monuments and building purposes" (248).

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(245) G.S.C., 1863, pp. 364-8.

(246) Ibid. p. 378.

(247) B.M., Vol. XI., p. [illegible]

(248) B M., Vol. I., p [illegible]

Wellington

Limestones of the Clinton, Niagara, Guelph and Onondaga formations are found in this county. The quarry and lime industries are important.

Niagara Formation

"It is probable that the whole formation [Niagara] is carried westward, in a narrow spur, on the axis of a small anticlinal. The effects of this are visible in the neighborhood of Rockwood, on the Eramosa, a branch of the Speed, in the fourth lot of the fourth range of Eramosa, where there is a considerable display of the upper part of the formation. On the one side of the undulation, the strata incline nearly north, at an angle of ten degrees, and on the other nearly south, at an angle of twelve degrees. The axis of the undulation would thus run about west, which would be nearly at right angles to the general trend of the strata through this part of the country. The undulation thus appears to be a small ridge running down the general slope of the strata, and producing but little effect on the distribution. Exposures of the rock occupy both sides of the stream, in vertical cliffs. The lower part consists of nearly eighty feet of light grey dolomite, in which divisional planes of stratification appear to be absent. Corals and broken encrinites abound in it, associated with other fossils. . . . On this mass there rest about twenty feet of buff or drab-colored dolomite, holding nodules and patches of chert; these are succeeded by about five feet of alternating black bitumino-calcareous shale, and dark brown very bituminous limestone. Corals are observed in some of these limestones, and crystals of galena are of common occurrence, both in the limestone and in the shale. In quarrying the dolomite beneath the shales at this locality, there was found a string or small vein of galena, which was followed for a distance of fifteen or twenty feet in one of the beds, to which the ore appeared to be confined. It was accompanied with smaller stringers holding the same mineral, which branched from the main one at irregular intervals; but the whole vein was quarried out without any appearance of a farther quantity of ore.

"Quarries have been opened both in the lower and upper masses of this encrinal magnesian limestone, which has been used in constructing the viaduct over the Eramosa, for the Grand Trunk Railway. That from the upper portion appears to be less porous than the lower, and of a better color for architectural purposes; but both are of excellent quality, and will probably be found durable. Caverns occur in the base of the lower mass. One of them extends about a hundred feet under the cliff, with a breadth of forty feet. The roof, which is eighteen feet high at the entrance, slopes irregularly downwards, and meets the floor at the distance just mentioned, leaving however a passage at either corner. One of these is said to lead to a large space beyond; from which other passages proceed. The roof is studded with small stalactitic incrustations.

"From Rockwood westward, the surface of the country falls at about the same rate as the supposed slope of the strata; so that, on arriving at Guelph, we should still have near the surface the beds of Rockwood, or strata not far removed from them. Exposures occur about five miles southwestward from Rockwood, at McFarlane's tavern, on the second lot of the third range, division C, of Guelph. They consist of about six feet of black bituminous shales, and limestones, similar to the highest beds at Rockwood, succeeded in ascending order by the following section, of which the last three feet belong to the Guelph formation:

"Dark brown strongly bituminous limestone, probably magnesian, in beds of about one foot each, 4 feet.

"Dark brown bituminous limestone, hard, brittle, and nearly compact, in several beds; the color is a shade lighter than the previous beds, 2 feet.

"Dark brown bituminous granular magnesian limestone, 6 feet 6 inches. inches.

"Pale buff or yellowish-white magnesian limestone, 3 feet. Total, 15 feet 6 inches.

"On the north side of the anticlinal, the summit of the Niagara series appears to run from Rockwood towards the east side of the township of Erin; between which and Mulmur it is only by the outcrop of the overlying formation that its western limit can be determined" (249)

Guelph Formation

"In Canada, the Niagara rocks are succeeded by a series of strata, which appear to be wanting in the state of New York. They are largely developed in the neighborhood of Guelph and Galt, and we have designated the series as the Guelph formation.

"The town of Guelph, in the township of the same name, is situated on the river Speed, about eight miles southwest from Rockwood. Here, in the bed of the stream, under the bridge on the

(249) G.S.C., 1863, pp. 330-31.

Brock road, there are exposed several feet of dark brown very bituminous dolomite; succeeded a little way up, on the left bank, by a mass of whitish coralline dolomite, which appears on the side of the road. About half a mile above Guelph, near the right bank of the Speed, there is a quarry in a whitish sub-crystalline dolomite, the strata of which are altogether about twelve feet thick. All the beds contain obscure casts of fossils; chiefly of corals and bivalve shells. . . . The strata are probably a little higher in the series than those of the same color at the bridge. Similar beds are extensively wrought a little below the town, and yield an excellent building stone. Some of the beds are burned for lime.

"Nearly five miles below Guelph, where a bridge crosses the Speed, on the town line between the fifth and sixth ranges of the Gore of Puslinch, there is a section, consisting, at the base, of fifteen feet of black, hard, compact, bituminous dolomite, without observed fossils; followed by seven feet of brown bituminous strata. On these are seven feet of buff or pale drab dolomites, holding obscure fossils. These exposures on the Speed are nearly in the strike of the strata. The light colored dolomites, which are here seen to rest upon dark colored bituminous strata, are regarded as the base of the Guelph formation." (250) (See also under Waterloo county).

"About fourteen miles north form Breslau, in Pilkington and Nichol, on the banks of the Irvine and Grand Rivers, near their junction at Elora, perpendicular cliffs of these dolomites occur, varying in height from seventy-five to eighty or eighty-two feet. The upper portion of these strata is probably near the top of the Guelph formation. The beds in descending order are as follows:

"1. Light drab or reddish compact magnesian limestone, in beds of from three to six inches, with small cavities, and cracks, lined with calcspar, 12 feet.

"2. Buff colored coralline magnesian limestone, 14 feet.

"3. Pale bluff or yellowish white compact magnesian limestone with a conchoidal fracture, in massive beds holding fossils, 56 feet. Total, 82 feet.

"At Fergus, which is on the Grand River, at such a distance above the mouth of the Irvine as would give 3 miles across the measures, a section occurs at Mr. Webster's mill, displaying about twenty feet of strata, which would underlie the preceding. About sixteen feet of these are a pale buff magnesian limestone, with casts and impressions of fossils. . . . . The remaining four feet consist of a grey hard magnesian limestone, which rests upon a mass of the same color, but somewhat closer grained, forming the bed of the stream. About a mile farther up the stream, on the land of Mr. James Webster, there are beds of pale yellowish-grey magnesian limestone weathering to a light buff. These would be still somewhat lower than the beds at Fergus. . . . Some of the Fergus beds yield good lime; they range from two inches to two feet in thickness, but are for the greater part thin and irregular, and although some of them are used for rough buildings, the stone for facing is brought to Fergus from Guelph. . . .

"The exposures which have been mentioned between Puslinch and Bentinck, belong to the upper part of the formation, and indicate the strike of its summit northward, as far as the Rocky Saugeen. In this region, with the exception of the space occupied by the westward spur of the Niagara series on the Rockwood anticlinal, the Guelph formation presents a breadth of about twenty-five miles, opposite to Puslinch, which gradually increases to thirty-five miles, opposite to Bentinck. This great breadth is probably due in part to the fact that the country rises with the general slope of the strata, to the edge of the eastern escarpment, though at a somewhat smaller angle; and in part also to a series of north and south undulations, which appear to exist in this region.

"Between Rockwood and Erin, the base of the formation forms a small sinus up the Speed, to Everton; while to the southward, it forms another sinus running down the stream to Eden. These two turns in the distribution of the rock are occasioned by an undulation transverse to the Rockwood anticlinal. Its axis, with a bearing a little east of north, would pass under Eden, Rockwood and Everton, and thence to Orangeville." (251)

"More rarely, the cavities thus formed have been filled up with calcareous matter, apparently replacing the substance of the shell; and in one place, great numbers of encrinal fragments have become replaced by a white sparry dolomite, whose color contrasts with the yellowish hue of the base. This last rock, which came from Strange's quarry, Rockwood, was, however, like the others, cellular, and a pure dolomite. It was submitted to analysis, with another specimen without fossils, from the same locality, a third from Howitt's quarry, Puslinch, and a fourth from McDonald's quarry, Guelph. The first and second gave respectively .90 and .65 per cent. of insoluble sand, while the others dissolved without remainder. All of these were pure dolomites, yielding from fifty-three to fifty-four per cent. of carbonate of lime, with traces of oxyd of iron." (252)

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(250) Ibid, 336-37.

(251) G.S.C., 1863, pp. 341-43.

"At Rockwood, in Eramosa, there is an exposure of more than 100 feet of crystalline dolomite belonging to the Niagara formation, in beds varying from a few inches to 10 feet in thickness. Of these, about 30 feet are nearly white, the remainder being of a light grey. This stone, which has not become discolored by exposure, has been used for the piers of the railway viaduct over the Eramosa river." (253)

"The quarries at Guelph are in the Guelph formation, and show a thickness of about fifteen feet of workable beds, which range from a few inches to three feet. The stone, which is easily worked and is of a superior kind for building purposes, has been extensively used in the town of Guelph. These dolomites are frequently somewhat cellular, but are strongly coherent." (254)

Onondaga Formation

In the townships of Maryborough and Peel, on the Canestoga, a branch of the Grand river, abundant fragments of the gypsiferous rocks mark the proximity of the outcrop of this formation.

Lime Kilns

In this county large lime-kilns are in operation at a number of points. Those at Rockwood produce a grayish-white lime from a gray, porous, fossiliferous limestone, used only for this purpose. The kilns in Guelph, at two different parts of the town, make a white lime; but the stone in addition is used for a variety of other purposes, mainly building, certain portions of the beds yielding a soft fine-textured, white stone, very easily cut and dressed. The strata, both narrow and wide, readily break into any desired size of slab for courses and sills. At Fergus and Elora are other kilns, also making white lime. The Fergus stone, at the quarry in the town, is also used extensively for road-making in some of our towns and cities.

Analyses

"Dolomite.—From the Wellington quarry, south half of the twenty-ninth lot of the Gore of the township of Puslinch. Geological position,—Guelph formation, Silurian.

"A light-gray, fine crystalline, massive dolomite. It was found to have the following composition : (255)

(After drying at 100 degrees C.—Hygroscopic water : 0.05 per cent.)

Carbonate of lime		54.25
Carbonate of magnesia		45.17
Carbonate of iron		0.22
Sulphate of lime		0.34
Alumina	trace	0.08
Insoluble matter	0.08	
		100.06"

"Dolomite.—From the Priest's quarry, on the bank of the river Speed, township of Guelph. Geological position, Guelph formation, Silurian.

"A light cream-yellow, yellowish-brown weathering, very fine crystalline, compact dolomite. Its composition was found to be as follows : (256)

(After drying at 100 degrees C.—Hygrosopic water 0.02 per cent.)

Carbonate of lime		53.97
Carbonate of magnesia		45.37
Carbonate of iron		0.16
Sulphate of lime		0.68
Alumina	trace	0.03
Insoluble matter	0.03	
		100.21"

Marl

"From a deposit three feet thick, underlying three feet of peat, in the neighborhood of the Eramosa branch of the Green river, township of Eramosa.

"The air-dried material is earthy, friable; color, light gray. It contains but few shells or root fibres.

"Its composition was found by Mr. F. G. Wait to be as follows:

(After drying at 100 degrees C.—Hygroscopic water equals 0.76 per cent.)

Lime	43.71
Magnesia	0.76
Alumina	0.16
Ferric oxide	0.29
Potassa	traces
Soda	traces
Carbonic acid	34.87
Sulphuric acid	0.34
Phosphoric acid	0.03
Silica, soluble	0.33
Insoluble mineral matter	10.36

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(252) G.S.C., 1863, p. 624.

(253) Ibid, p. 821.

(254) Ibid, p. 820.

(255) G.S.C., 1895, p. 17 R.

(256) Ibid, pp. 16-17 R.

Organic matter, viz., vegetable fibre, in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water	9.79
	100.64

"Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 78.05 per cent. carbonate of of lime.

"The insoluble mineral matter was found to consist of: (257)

Silica	7.74
Alumina	1.52
Ferric oxide	0.37
Lime	0.24
Magnesia	0.08
Alkalies (?)	0.41
	10.36"

A Drill Section

"A record has also been obtained from a boring made at Guelph, where we find:

	Feet
Drift	15
Blue slate	50
Niagara and Guelph	100
Gray slate	5
Red slate	5
Gray slate	10
Blue slate	2
Clinton	10
Blue slate	20
Hard limestone	7
Blue shale	8
Medina sandstone	12
Blue shale	7
Red Medina	400
Hudson river	500
Utica	300
Trenton	110
Total	1,562

"From the top of the Trenton to the surface of the rock at Guelph is therefore 1,437 feet. Assuming the thickness of the various strata to be approximately the same at St. Marys, we get the surface rock at Guelph to lie in the middle of the 716 feet of limestone recorded at Stratford. This would make 323 feet of Guelph limestone removed by erosion at that place. On the other hand, if we consider the 50 feet of blue shale as analogous to the 40 feet at Stratford, then the 716 feet represent the Niagara and Guelph, showing therefore a considerable increase in thickness towards the west. At Guelph this slaty bed lies 15 feet down, and at Stratford 546 feet. Subtracting these figures from the elevations of the respective places (1057 and 1207 feet above the sea) we find that the dip of the beds is 381 feet in the 40 miles separating the two places. This however must not be considered the true dip, which is in a more southwesterly direction and would therefore be somewhat greater. Quite recently a well was sunk at St. Marys, the record of which, whether by accident or design, seems to have been very carelessly preserved. The following notes are due to Mr. Thomas Cox, who had a certain interest in the drilling:

Water at 550 feet.

Brine at 985 feet.

Sulphur water at 1185 feet.

In gray Medina sandstone at 1510 feet." (258)

Wentworth

In the escarpment which runs through this county representatives of three formations are found. At the base of the escarpment, where not covered by talus, the red shales of the Medina are exposed; above and resting on these is the Clinton limestone, on which rest the shales and limestones of the Niagara formation which forms the summit of the escarpment. The limestones in these formations are magnesian, and are thus not adapted for use in certain industries. In the vicinity of the city of Hamilton, and elsewhere in the county there are important quarries which produce stone for structural purposes. A considerable amount of the stone is crushed and used in the paving of streets and roadways. The limestone for the Hamilton blast furnace is also quarried in the county.

"Proceeding westward [along the escarpment of which the upper part is composed of the Niagara formation,] the volume of the black shales diminishes, while that of the limestones beneath them augments; and in the neighborhood of Hamilton and Ancaster, we have the following succession, in ascending order:

"1. Light grey magnesian limestone, weathering yellowish, and holding Pentamerus oblongus in great abundance; 1 foot 6 inches.

"Grey magnesian limestone, with geodes of calcspar in the lower, and broken encrinites in the upper part; 9 feet 3 inches.

---

(257) G.S.C., 1894, p. 29 R.

(258) B.M., Vol. XII., p. 150-51.

"2. Bluish argillaceous and arenaceous shale, with thin bands of sandstone; 5 feet.

"Grey arenaceous limestone; 3 feet 5 inches.

"Bluish shale; 1 foot.

"Bluish-grey argillaceous limestone, with geodes of calcspar; this is probably fit for water cement; 5 feet 7 inches.

"3. Whitish limestone, with geodes of calcspar, containing nodules and patches of chert in considerable abundance; 16 feet 6 inches.

"4. Bluish-black bituminous shale, with thin bands of limestone holding fossils; the shale, which is in very thin laminae, presents surfaces covered with bituminous matter, and nodules of chert are sometimes met with in the limestone; 6 feet.

"5. Grey, strongly bituminous limestone, very unevenly deposited; 5 feet.

"Reddish grey, drab-weathering, bituminous, magnesian limestone, moderately thin-bedded; with partings of bituminous shale. The limestone holds disseminated crystals of galena associated with pearl-spar; 5 feet.

"6. Grey compact tough magnesian limestone; 3 feet.

"Bluish magnesian limestone, weathering into small pits on the surface, and containing small nodules of a carbonaceous matter, resembling coal; 3 feet.

"Blue and grey compact magnesian limestones; 3 feet.

"Gray compact magnesian limestone; 3 feet.

"Bluish magnesian limestone, weathering into irregular pits on the surface of the beds; the rock holds small masses or carbonaceous matter as above; 3 feet.

"Bluish-grey compact magnesian limestone, presenting under the influence of the weather a rough pitted surface, 5 feet.

Total 78 feet 3 inches.

"The limestones, 5, which overlie the black shales, 4, form the upper part of the ridge which extends between the falls of Niagara and the village of Ancaster. They are highly bituminous, and for the most part magnesian for the whole distance; and they abound in fine cabinet specimens of selenite, celestine, pearl-spar, blende and galena. Crystals of the latter mineral exist in greater or less quantity, in nearly all the limestones from the Pentamerus band to the summit of the upper beds; but they are in the greatest abundance in the latter . . . .

"Northward from this the black shale, 4, maintains for a few miles the thickness which it presents in the last section, and it is recognized above the beds already described as composing the Clinton formation, on the sixteenth and seventeenth lots of the first range of Flamborough West, near Dundas. In ascending order these succeeding beds are:

"1. Grey magnesian limestone, with Pentamerus oblongus in abundance; 1 foot.

"2. Blue magnesian limestone, in very even and regular beds, of which the thickest are from sixteen to eighteen inches; separated by partings of bluish-grey shale. The limestone is used for building purposes; 7 feet.

"3. Light grey magnesian limestone in one bed; this is used for building purposes and is known by masons and quarrymen as the five foot band; 5 feet 6 inches.

"4. Bluish-grey calcareo-arenaceous shale, passing into black; it is hard and solid in the bed, but disintegrates and crumbles into a clay when exposed to the atmosphere, with the exception of thin interstratified beds, which resist the weather; 6 feet.

"5. Bluish-grey magnesian limestone, composed chiefly of broken encrinites. The beds are from three to four feet thick, and are separated by very thin layers of buff colored argillaceous shale. This limestone forms an excellent building stone, for which it is used, as well as for burning lime; 19 feet 3 inches.

"6. Dark bluish-grey argillaceous shale; this is a well marked band, and may be traced for some distance on the strike; 1 foot.

"7. Blue and grey limestone, including bands of white, buff and grey chert, and thickly studded with chert nodules; 20 feet.

"8. Brownish bituminous magnesian limestone, with small disseminated crystals of galena, and a few fossils; 10 feet.

"9. Grey bituminous magnesian limestone in rough irregular beds; 5 feet.

"10 Measures concealed; 5 feet.

"11. Black bituminous magnesian limestone in thin irregular layers; 2 feet.

"12. Black bituminous shale; 1 foot.

"13. Dark brown very bituminous magnesian limestone, in thin beds, with rough irregular surfaces; 2 feet.

"14. Dark brown bituminous magnesian limestone, holding disseminated crystals of galena; 5 feet.

"15. Black fissile shale; 2 feet.

"16. Dark very bituminous magnesian limestone, with black shale at the top, and with numerous fossils; 3 feet.

"17. Dark brown bituminous magnesian limestone; 2 feet.

"18. Black bituminous shaly limestone; 1 foot.

"19. Measures concealed; 2 feet.

"20. Black bituminous magnesian limestone, with obscure fossils in the lower part; 8 feet.

"21. Dark grey slaty limestone in thin layers, with an occasional band of six inches; 4 feet 6 inches.

"22. Dark brown bitumino-arenaceous shale, with fossils; 6 inches.

"23. Brownish bituminous limestone, with partings and thin bands of dark brown bituminous shale; 15 feet.

Total, 127 feet 9 inches.

"In this section the black shale of the Niagara Falls is supposed to be represented by the bed, 4, underlying the massive encrinal limestones, 5; but it produces no marked feature in the form of the surface.

"The rocks of the section in the neighborhood of Dundas, however, form two separate and distinct terraces. The lower and more marked escarpment presents the strata beneath the band of cherty limestone, 7, which caps the precipice at Flamborough West. The upper escarpment, composed of the dark colored bituminous magnesian limestones and their accompanying beds, rises more gradually, in a succession of steps; terminating at the summit in a wide extent of table-land." (259)

Niagara Formation

"Across the whole of the western peninsula, the summit of the Niagara formation is so much covered with drift, that it would be very difficult to trace it with any degree of precision; or to connect in an intelligible manner the scattered exposures of Niagara strata to the westward, with the rocks of the lower escarpment, were it not for the aid afforded by the outcrop of the succeeding rock. Above the east end of the Niagara and Hamilton ridge, the upper limit of the formation probably reaches the lower part of the Chippewa Creek; and passing by Port Robinson on the Welland Canal, it may cross the road between Hamilton and Port Dover, within two or three miles of the former place. It is not, however, certain where it folds over the Dundas anticlinal, there being no exposures whatever upon the axis. The most western appearance of the upper part of the formation, on the south side of the anticlinal, occurs in the vicinity of Ancaster; the most western on the opposite side, about two miles north of Ancaster, on the third lot of the first range of Flamborough West. It may be inferred from the trend of the formation on each side, and from the general shape of the country, that its summit would fold over the axis of the anticlinal, on the line between the townships of Ancaster and Beverley, at about the thirty-fourth lot." (260)

"Between the head of the inclined railway at Hamilton and the village of Ancaster no rock exposures are seen; at this latter point however, we may pass over the edge of the escarpment and encounter Niagara limestones where the main road from Hamilton enters the village. Here several quarries are in operation. One owned by Mr. Middleton is situated on the north side of the road, and presents at the top five feet of so-called honeycomb rock. This is a cavernous limestone the spaces in which are lined by small quartz crystals or filled with gypsum and, in some instances, barite. In the better preserved parts of the honeycomb these cavities are seen to arise from the weathering away of masses of a favositoid coral probably Favosites gothlandica. This rock is said to make a sandy lime and consequently is used mostly as road metal. The next stratum is a heavy limestone bed in which fine crystallization has obliterated all trace of fossils. This bed is somewhat shattered in places by jointing, but still furnishes large quantities of excellent building stone. Underlying the bed are three feet of thin limestones, five feet of well laminated limestone, five feet of solid finely crystalline limestone said to chisel excellently, and eight inches of loose material. On the opposite side of the road quarries have been opened by Messrs. Guest and Hendrie which present practically the same series of rocks. An analysis of the best rock from these quarries shows it to be a typical dolomite with the following composition: (261)

	Per cent.
Moisture	0.23
Insoluble matter	1.60
Carbonate of lime	53.30
Carbonate of magnesia	43.13"

"Dundas, Ontario.—At this locality the Niagara formation also affords a dolomite, a specimen of which proved on analysis to contain much more carbonate of magnesia than was found in the specimen from the same formation at Grimsby. The analysis gave:

Carbonate of lime	51.58
Carbonate of magnesia	41.65
Carbonate of iron	0.62
Insoluble matter	5.88
	100.00

"The specimen was brownish-grey, compact and rather earthy" (262)

Quarries

The limestone from the quarry near Rymal station, used as a flux at the Hamilton blast furnace, is said by the chemists there to have approximately the following percentage composition:

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(259) G.S.C., 1863, pp. 323-27.

(260) Ibid, p. 329.

(261) B.M., Vol. XII., pp. 141-42.

(262) G.S.C., 1876-77, p. 487.

Lime	30.54
Magnesia	19.50
Alumnia and ferric oxide	0.94
Silica	0.33

The rock from the quarry at Vinemount, Hamilton, is said to be of about the same character, but tends to possess more sulphur and silica.

Barnes' quarry at Rymal has a face of about 21 feet, with a thin layer of soil at the surface. This stone is better suited for furnace use than that near the face of the escarpment, the upper layers of which contain chert nodules. There are one or two other small quarries near Rymal.

From the drill hole put down to a depth of 200 feet, it is said, from the surface in Barnes' quarry, gas and salty water spout up a short distance at intervals. The gas forces up the water and burns when lighted at the end of the iron pipe set into the hole.

An average analysis of the stone from Barnes' quarry used at the Hamilton blast furnace for a considerable period, is given on a preceding page, in the section devoted to smelting.

York

Rock exposures in the greater part of this county are few in number. The southern part is underlaid by the Hudson River formation, and exposures are seen along the courses of the streams. The Utica and Trenton formations, which run in bands across the northern part, are covered heavily with drift material.

The Bureau of Mines has received returns of lime production from the vicinity of Baldwin, Vachell and Virginia post offices, in the township of Georgina. This lime is apparently derived from drift boulders or "field stone," which have been transported from the northeastward during the ice period.

"Between the river Rouge in the township of Pickering [Ontario county] on the east, and the river Credit in the township of Toronto [Peel county] on the west, sections of the Hudson River formation may be seen on almost all the intervening streams. The formation here consists of a series of bluish-grey argillaceous shales, enclosing bands of calcareous sandstone, sometimes approaching to a limestone, at irregular intervals and of variable thickness. In some instances the bands are of a slaty structure, splitting into thin laminae in the direction of the beds; in others they have a solid thickness of a foot; but in few cases do they maintain either character for any great distance. The sandstones, while in the beds, are hard and solid, and upon fracture exhibit a gray color, with much of the appearance of limestone; but by long exposure to the weather they turn to a dark brown, and ultimately crumble and decay. These sandstones generally abound in calcareous fossils, which in some places predominate so as to give rise to beds of impure limestone; these beds are however rare. . . .

"The banks of the Credit, the Etobicoke, the Minaco, the Humber and the Don, for certain distances from the lake shore, expose sections exhibiting sixty feet or more of these strata; but advancing northward, the formation becomes concealed by the great accumulation of drift, of which the interior of the country is composed. At Weston, on the Humber, near to the townships of Etobicoke and York, some good limestone occurs, and at Fisher's mill, below Dundas Street, on the same river, there is more of the same material. At the latter place, the banks of the stream rise to a height of more than a hundred feet, of which from fifty to sixty are composed of the Hudson river shales and sandstones, while the upper part consists of sand and gravel." (263)

"In the township of York, on a small tributary of the Don, beds of tufa occur from twelve to fifteen feet in thickness, and are overlaid by sand and clay" (264)

It is interesting to know that drill holes, which have been put down in the vicinity of Toronto, in search of gas and oil, after passing through the Hudson river and underlying Palaeozoic formations, have penetrated crystalline limestone of the Archaean system.

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(263) G.S.C., 1863, pp. 212-213.

(264) Ibid, p. 455.

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Sclater's quarry, St. Marys; another view. Perth County

St. Marys quarries. Product used for building, and waste rock for road metal. Opening is 200 by 400 feet, and 20 feet deep. Perth County.

Horseshoe Quarry, St. Marys. Product, building stone. Perth County.

Lime kiln at Galt (Standard White Lime Co.) Old "set" kiln, one of a series of three. Waterloo County.

Lime kilns at Sherkston quarry, using natural gas as fuel. Welland County.

One of the crushers at Sherkston quarry. Welland County

E. Harvey's limestone quarries at Rockwood. Wellington County.

E. Harvey's lime kiln, Rockwood. Quarry above and to right. Wellington County.

Roman Catholic Cathedral, Guelph; built of limestone from Guelph quarries (Guelph formation).

"Kennedy's" quarry and kilns, Guelph. (Standard White Lime Co.) Wellington County.

"Kennedy's" kilns, Guelph, (Standard White Lime Co.) Wellington County

"Kennedy's" quarry, Guelph, (Standard White Lime Co.) Product used for building, and waste rock burned to lime. When taken out stone is soft and easily worked, but hardens on exposure.

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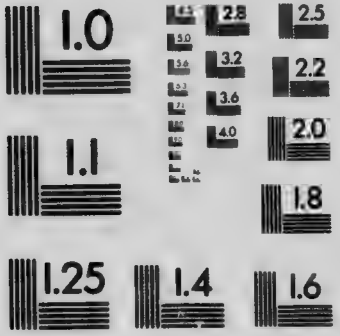

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